Both Plan and Map are the graphical representations of the features on horizontal plane but plan is a large scale representation while map is a small scale representation.

Geodetic Survey	Plane Survey
It is done for fixing widely spaced control points.	It is done for Engineering projects. Use for small area.
Geodetic surveying is done by Department of National Survey of India.	Earth surface is assumed to be flat.
Large areas of earth's surface involved	It is more accurate.

Note: The effect of the curvature of earth's surface is taken into account only if the extent of survey is more than 195.5 km².

- **The difference in the length of an arc and its subtended chord on earth's surface for a distance of 18.5 km is about 10 mm.**

Classifiaction of Surveying Based on Purpose

(*i*) Topographical Survey: It is conducted to obtain data & to make a map indicating inequalites of land surface. Topographic Survey is done to determine the Natural features of a Country. Scale range is 1 : 25000 to 1 : 1000000.

(*ii*) Hydrographic Survey: It is conducted on or near water bodies. Marine survey is also one of it's type.

(*iii*) Engineering Survey: It is used for design & construction of new routes (roads & railways). Also used to calculate for route alignment.

(*iv*) Geological Survey: It is conducted to obtain data of different strata of earth's surface for the purpose of geological studies.

(*v*) Cadastral Survey : It is used to produce plans of property boundries for legal purpose. The revenue chain is used in cadastral surveying. Also called public land survey.

(*vi*) Astronomic Survey: It is conducted for determination of azimuths, latitudes, longitudes, local time etc. at various places on the earth by observing heavenly bodies. Absolute location of a point on earth surface is obtained by it.

- **Archaeological survey is done to collect information about old and nelic structures.**
- **Reconnaissance Survey is a kind of pre liminary survey which is performed to find out method of survey to be adopted and its rough cost.**

Classification based on instrument used -

Chain surveying , Compass surveying, Theodolite survey, Levelling survey, Contouring, EDM survey, Photogrammetric survey, Tacheometric survey.

- **Correct Sequence of Surveys**
  - **(a) Traffic Survey**
  - **(b) Reconnaissance Survey**
  - **(c) Preliminary Survey**
  - **(d) Detailed Survey/Location Survey**

Principles of Surveying:

(*i*) Work from Whole to Part: So as to localise the error and prevent their accumulation.

(*ii*) Locate a Point by Atleast two Measurements:

Error due to use of wrong scale:

- **Correct length**

$$= \boxed{\frac{\text{R.F of wrong scale}}{\text{R.F. of correct scale}} \times \text{Measured length.}}$$

- **Correct Area**

$$= \left(\frac{\text{R.F of wrong scale}}{\text{R.F. of correct scale}}\right)^2 \times \text{Calculated Area}$$

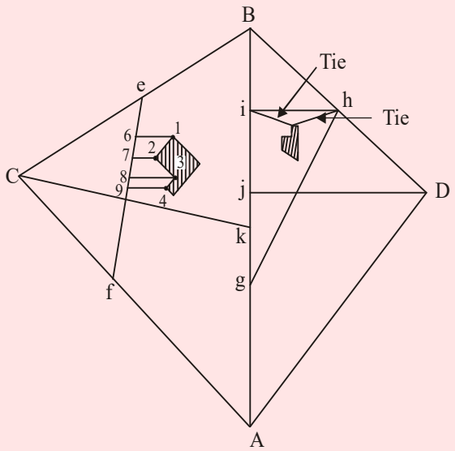
- **Principal of Least Square:**

$$E_m = \pm 0.6745\sqrt{\frac{\sum v^2}{n(n-1)}} = \frac{E_s}{\sqrt{n}}$$

Units of Measurement

1 ft. = 0.3 m	1 mile = 1.609 km
1 yard = 3 ft	1 acre = 43560 sq. ft.
1 hectare = 2.471 acre	1 Nautical mile = 1.852 km

Terms Used in Large Survey Area



(a) Main station : It is a point in chain survey where two triangle sides meet.

(b) Main survey line: Chain line joining two main survey stations,

(c) Tie station or subsidiary station: Station on survey line joining main stations.

(d) Proof line or check line: Provided to check the accuracy of the field work.

(e) Offsets: These are lateral measurement made w.r.t. chain line which may be oblique or perpendicular in nature.

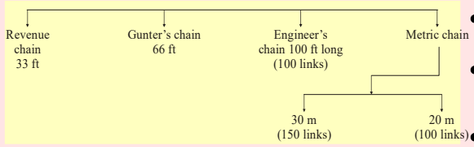
(f) Base line: Longest survey line from which direction of all other sruvey lines are fixed.

(*g*) Chainage: Distance measured along the main survey line in direction of progress of work.

- **Double line field book is most commonly used for recording ordinary chain survey work.**

Well Conditioned Triangle: Triangle in which all intersections of lines are clear. Angle's between the lines for clear plotting purpose. Intersections should be 30° to 120°. The best angle is 56° 14' for this condition. An equilateral triangle is the most appropriate well conditioned triangle.

Surveying chain: It is used where very high accuracy is not required. A chain consist of a number of large links made up of galvanized mild steel wire of 4 mm diameter.



Note: As per IS specifications, every metre length of the chain should individually be accurate to within ± 2mm when measured under a tension of 80 Newton.

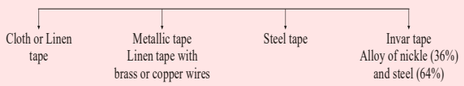
(a) 1 mile = 80 Gunter's chain

(b) 1 acre = 10 × (Gunter's chain)²

(c) The overall length of chain should be within the limits given below

(i) 20 m ± 5 mm for 20m chain.(ii)30 m ± 8 mm for 30m chain

(ii) Tapes:


Cloth or Linen tape
Metallic tape Linen tape with brass or copper wires
Steel tape
Invar tape Alloy of nickle (36%) and steel (64%)

(iii) Pegs: To mark definite points on ground temporarily.

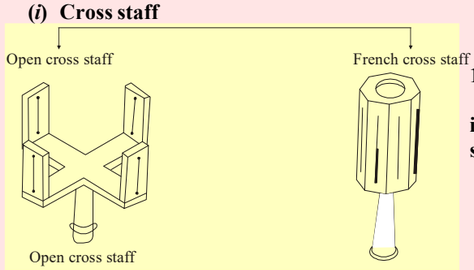
(iv) Arrows: It provides a check over the length of line as entered in the field notes.

(v) Ranging rods: To locate intermediate points such that these points lie on straight lines joining the end stations.

(*vi*) Offset rod: Similary to ranging rod with a sout open hook at the top.

Equipments for Measurement Right angles

(*i*) Cross staff



- **Accuracy of the french Cross Staff is less than that of an open cross staff. But french cross staff can be set out at an angles of 45° and 135°.**

(*ii*) Optical Square: Pocket instrument, more convenient and accurate than a cross staff.

- **Optical Square is used to establish two Points at right angle. The principal used is of Double reflection Hence, Angle between two mirrors is 45°.**

Tap Corrections

- **Correction for Slope:**

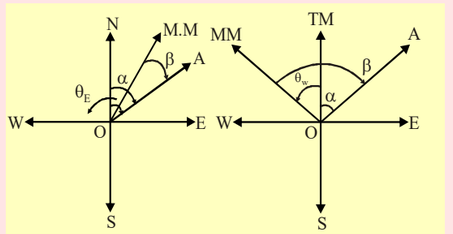
$$C_s = -L - \sqrt{L^2 + h^2}$$

$$C_s = \frac{h^2}{2L}$$

- **Correction for mean sea level**

$$C_h = \frac{-Lh}{R}$$

- **Correction for Temperature: $C_t = \alpha (T_m - T_o)L$**
- **Correction for pull or Tension: $C_P = \left(\frac{P - P_s}{AE}\right)L$**
- **Correction for Sag: $C_s = -\frac{L_1(wL_1)^2}{24P^2}$**
- **Bearing: Direction of a line with respect to fixed meridian is called bearing.**
- **True Meridian/Bearing**
  - **→ True meridian is a line joining True North pole, True South Pole end and point of reference. It never changes with time.**
  - **→ Angle measured for any line w.r.t True Meridian is called Ture bearing.**
- **Bearing Taken W.r.t magnetic meridian is called magnetic Bearing.**



Magnetic Declination

- **At any place horizontal angle b/w True Meridian and Magnetic Meridian is called magnetic Declination.**

Fore bearing and Back Bearing: B.B = F.B ± 180°

Local Attraction: If the difference b/w fore bearing and back bearing is 180°, the the adjoining stations are free form local attraction.

(*i*) Isogonic Line: Lines passing through the points on earth surface at which the declination is the same at given time. They rediate from North and South pole and follow irregular paths.

(*ii*) Agonic Lines: Lines passing through points of zero declination. True meridian and magnetic meridian coincides with each other.

CIVIL BOOSTER - Dnt trust us, Just Check it's content & Then Go for it - (LEAVE THE REST. GET THE BEST) . Available on amazon flipkart.

Variation of magnetic declination			
Secular variation	**Annual variation**	**Diurnal variation**	**Irregular variation**
Due to over a long period of time due to gradual shift in earth's magnetic field.	Due to revolution of earth around the sun. (Yearly)	Due to rotation of earth about its own axis. It's more at pole, in day & summer time.	Due to magnetic disturbances in earth's magnetic field.

Prismatic Compass	Surveyor Compass
• Smaller in size (85 - 110 mm diameter)	• Bigger (circular box of size 150 mm dia)
• Broad Needle with aluminium ring is used	• Measurement quadrantal bearings
• Sighting of the object & reading of the bearing are done simultaneously	• First Object is sighted & then reading of bearing is taken by moving around the looking down from glass cover.
• Agate cap is fitted with prismatic compass	
• Temporary Adjustment Centering, Levelling, focussing.	• Temporary Adjustment Centering & Levelling.
• Tripod is not essential	• Tripod is essential
• Graduation is inverted because we have to see them through prism	• Graduation is erect as we can seen from it top
• Readings are in W.C.B., having 0° at south, 90° at West, 180° at North & 270° at East	• Edge bar type magnetic needle is used
	• It has 0° at N & S, 90° at E & W

Least count of Prismatic Compass is 30', surveyor compass 15', vernier scale - 0.1mm, micrometer - 0.01 mm, theodolite (20" & 15 second), for levelling staff - 5 mm.

Obstalces in chaining

- **Forest, Hill - Obstacle to ranging but not chaining**
- **Small pond, small bend in river - Obstacle to chaining but not ranging**
- **A big building - Obstacles to both chaining & ranging**

Angular measurement	Linear measurement
(a) Loose needle method	(a) Taping or chaining
(b) Fast needle method	(b) Tacheometric method
(c) Method of deflection angle	(c) Electronic distance measuring instrument (EDMI)
(d) Method of direct angle	
(e) Method of included angle	

Accuracy order: Coordinate method > Method of included angle > fast needle method > Loose needle method.

Dip: The angle made by the lines of magnetic force with the earth's surface is called dip. Magnetic needle becomes horizontal at equator but becomes vertical at magnetic poles.

Latitude and Departure

- **Projection of a line on N-S direction is called latitude.** $\boxed{L = +l\cos\theta}$
- **Projectione of a line on E-W direction is called departure.** $\boxed{D = l\sin\theta}$

Adjustment of closing Error

- **Sum of all internal Angles of a closed Traverse. = (2n – 4) × 90° where n = No. of sides.**
- **Sum of all deflection Angle = 360°**
- **Sum of latitude** $\boxed{\sum L = 0}$
- **Sum of departure** $\boxed{\sum D = 0}$

Closing error In the Traverse $\boxed{e = \sqrt{(\sum L)^2 + (\sum D)^2}}$

Bowditch's Method (Compass Rule)

Permissible error in linear Measurment

$$= \boxed{e \propto \sqrt{\ell}}$$

Permissible error in angular measurement

$$= \boxed{e \propto \frac{1}{\sqrt{\ell}.}}$$

- **Correction to latitude:** $C_L = \Sigma L \times \frac{1}{\Sigma \ell}$
- **Correction due to departure:** $C_D = \Sigma D \times \frac{1}{\Sigma \ell}$
- **Transit Method:** $C_L = \Sigma L \times \frac{L}{L_r}, C_D = \Sigma D \times \frac{D}{D_r}$

Axis Method

Correction of any length

$$= \text{That length} \times \frac{\frac{1}{2}\text{closing error}}{\text{Length of Axis}}$$

Direct levelling methods

Simple | Differential | Profile | Fly | Check | Cross-section | Reciprocal | Precise

Sensitivity of level tube can be increased by increasing radius, diameter of tube, length of tube and decreasing the temperature, viscosity of liquid, the roughness of the inner wall of the tube.

$$\phi = \frac{nd}{R} = \frac{S}{L}, \quad \boxed{\phi = \frac{d}{R} = \frac{s}{nL} \text{Radian}}$$

- **Check in Height of Instrument Method**

$$\sum BS - \sum FS = \sum Rise - \sum Fall = \text{Last RL} - \text{First RL}$$

Note: First reading made on a point of known reduced level is always a Back sight reading.

Rise and Fall Method	Height of Collination
1. Arithmetic check Σ(Back sights) – Σ(fore sights) = Σ(Rise) – Σ(fall) = Last RL – first RL	1. Arithmetic check Σ(BS) – Σ(FS) = Last RL – first RL
2. Check for intermediate reading is done using ΣRise – Σfall	2. Reduction is easier in it.
3. It is well suited for determining the differences of levels of two points where precision is required.	3. It is most suited for longitudinal /cross-sectional levelling and Contouring.

- **Curvature:** $C_c = -\frac{d^2}{2R} = -0.0785d^2$.
- **Refraction:** $C_r = \frac{1}{7}\left(\frac{d^2}{2R}\right)$
- **Final Combination Correction**

$$C = C_c - C_r = \frac{6}{7}\left(\frac{d^2}{2R}\right),$$

$$C = -0.06735d^2$$

$d = 3.85\sqrt{h}$, d = in km and h = in meter.

Reciprocal Levelling:

- **The true difference Elevation:**

$$H = \frac{1}{2}[(h_a - h_b) + (h_a' + h_b')]$$

- **Determining Areas: Mid ordinate rule Δ = Area = Average ordinate × Length of base**

$$\Delta = \frac{O_1 + O_2 + ... + O_n}{n} \times L$$

- **Simpson's One-Third Rule**

$$\Delta = \frac{d}{3}\left[(O_1 + O_n) + 2(O_3 + O_5 + ... + O_{n-2}) + 4(O_2 + O_4 + ...O_{n-1})\right]$$

Methods of tacheometry -

(a) Tangential method - In it, observations are made for vertical angles & staff intercepts are obtained with cross wires only. Stadia wires are not used at all.It is faster than stadia hair method.

(b) Range finding - It is used to find out the horizontal distance & direction of a line without going to far end of the line. The equipment used is known as range finder.

(c) Stadia method - (i) Fixed hair method - In it, parallactic angle is kept fixed & the staff intercept is varied.

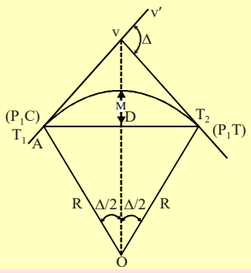
(ii) Moveable hair method - It is also called subtense method .

Fixed hair system: In this system the vertical distance between the upper and lower stadia hair is fixed and this fixed distance is called as stadia interval (I).

- **The stadia diaphragm consist of two stadia hairs at equal distances.**
- **Fixed Hair Method**

$$D = k \times S + C, \qquad K = \frac{f}{i} = 100$$

Addition Constent C = (f + d), f = focal length of object , S = Staff intercept,i = Stadia interval



$$l = \frac{\pi R \Delta}{180}$$

$T = R \tan \Delta/2$

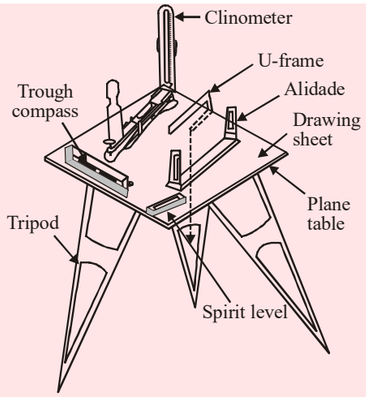
$L = 2R \sin \Delta/2$

$M = R(1 - \cos \Delta/2)$

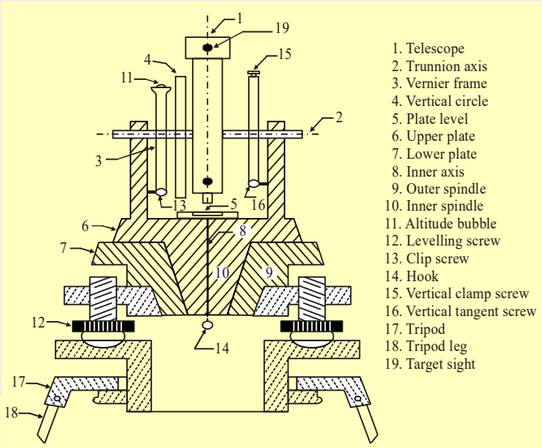
$E = R\left(\sec\frac{\Delta}{2} - 1\right)$

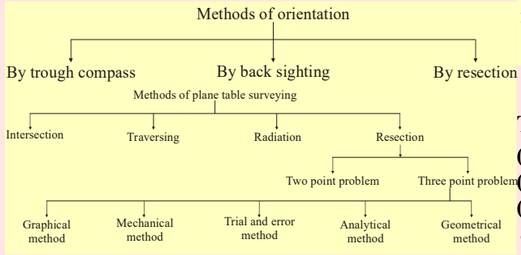
Instrument	Purpose
Abney level	To measure slope, cross section, to find gradient
Planimeter	To measure area very accurately
Pantagraph	Used to reduce/enlarge the maps
Hand level	To trace contours
Sextant	To measure horizontal & vertical angle

CIVIL ENGINEERING ROCKET CHART
FOR QUICK REVISION



Plain table with accessories

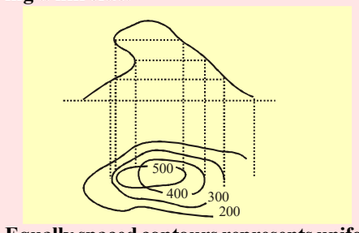




Characteristics of Contour

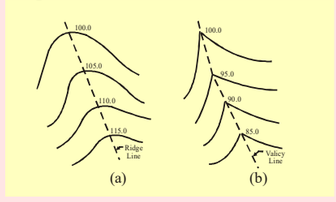
(i) A zero meter contour line represents the constaline. When no value is represented, it indicates a flat terrain.

(ii) Two contours intersect eachother only in case of overhanging cliff or a cave penetrating a hill side.



(iii) Equally spaced contours represents uniform slope.

(iv) A watershed or edge line contour crosses the valley contour at right angle. Converally the contours are not visible on the grounds excepts in the case of shore lines.



(v) Direction of steepest slope is along the shortest distance between the contours.

(vi) Two contour lines having same elevation cannot unite and continue as one line.

Total station used for:

(a) Establishing horizontal control.
(b) Establishing vertical control.
(c) Remote object height determination.

- **Levelling staff are of two types:-**

(a) Self reading staff:-

Solid staff, folding staff (used in our country), telescopic staff.

(b) Target staff:-

Height - 4m, thickness - 18 mm, width - 75 mm, least count - 5 mm.

Generally used scales for measurement purpose are :

S.N.	Type of Scale	Scales	R.F. value
1.	Cadastral map	1 cm = 5 m to 0.25 km	$\frac{1}{500}$ to $\frac{1}{5000}$
2.	Topographical map (a) Buildings	1 cm = 2.5 km 1 cm = 10 m or less	$\frac{1}{1000}$ or less
	(b) Town planning	1 cm = 50 m to 100 m	$\frac{1}{5000}$ to $\frac{1}{10,000}$
	(c)Location map	1 cm = 50 m to 200 m	$\frac{1}{5000}$ to $\frac{1}{20,000}$
	(d) Small Scale Topographic Survey (e) Mines	1 cm = 0.25 km to 2.5 km 1 cm = 10 m to 25 m	$\frac{1}{25,000}$ to $\frac{1}{2,50,000}$
	(f) Forest Scale	1 cm = 0.25 km	
3.	Preliminary survey of rails & roads	1 cm = 10 m to 60 m	

S.SOROUT, 9255624029

FOLLOWING BOOKS AVAILABLE BY

CIVIL Ki GOLI

PUBLICATION:

1. **CIVIL Ki GOLI**
2. **CIVIL BOOSTER**
3. **REASONING Ki GOLI**
4. **HARYANA Ki GOLI**
5. **SOLUTION OF CIVIL Ki GOLI**
6. **ELECTRICAL & MECHANICAL ENGINEERING ROCKET CHART**
7. **UTTAR PRADESH Ki GOLI**
8. **UTTRAKHAND Ki GOLI**
9. **PUNJAB Ki GOLI**
10. **WEST BENGAL Ki GOLI**
11. **HINDI ROCKET CHART**
12. **CIVIL CAPSULE**

Roman Roads → Tresaguct Construction → Metcalf Construction → Telford Construction → Macadam Construction

Nagpur Plan	Bombay Plan	Lucknow Plan
→ 1943–1963 → Road density 16 km/100 km²	1961–1981 Road density 32 km/100 km²	1981–2001 Road density 82 km/100 km²
→ Recommended star & grid pattern	→ Construction of 1600 km of Expressway	Rectangular & block pattern

Important year's of highway development

1. Nov. 1927 → Jayakar committee formed.
2. Feb. 1928 → Recommendations by Jayakar committee
3. 1929 → central road fund (CRO - 1930)
4. 1934 → Indian road congress
5. 1939 → motor vehicle act
6. 1943 – 1963 → Nagpur road plan (finished in 1961)
7. 1952 → Central Road Research Institute (But some books recommended 1950), Google wikipedia - 1950
8. 1956 National highway act
9. 1961 – 1981 → Bombay road plan
10. 1981 – 2001 → Lucknow road plan

Chandigarh → Rectangular and block pattern
New Delhi → Radial and circular pattern at connaught place.
Nagpur road plan formulated star and grid pattern.

- **SSD =** $v.t + \frac{v^2}{2g(f \pm 0.01n)}$ $= 0.278v.t + \frac{V^2}{254(f \pm 0.01n)}$
- **OSD** $= V_b.t + (V_b.T + 2S) + V.T$

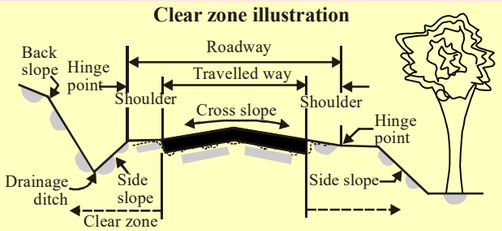
$= 0.278V_b.t + 0.278V_b.T + 2S + 0.278V.T$

$T = \sqrt{\frac{4S}{a}}$, $v_b = v - 4.5$, $\frac{v^2}{gR} \le f$

$e + f = \frac{P}{w} = \frac{v^2}{gR}$, ⇒ $v = m/sec.$

1. The parking lane should have a minimum of 3.0 m width in the case of parallel parking.
2. Minimum width of cycle Track is 2m.
3. Right of way/land width is the width of land required for the road along its alignment.
   - Maximum No. of vehicles can be parked with 90° Angle parking.
   - In Highway construction, Rolling start from sides and proceed to centre.

Clear zone illustration



Sight Distance: The distance from which any types of obstruction on the road length could be visible to the driver from some distance ahead

Stopping Sight Distance (SSD)
Intermediate Sight Distance (ISD)
Overtaking Sight Distance (OSD)
Head Light Sight Distance
Safe Intersection Sight Distance

- **Super Elevation Design:** $e = \frac{(0.75V)^2}{127R} = \frac{V^2}{225R}$
- **Ruling minimum radius of Horizontal curve:**

$R_{rulling} = \frac{V^2}{127(e+f)}$,

- **Extra Widening of Pavement:**

$W_e = W_m + W_{PS} = \frac{nl^2}{2R} + \frac{V}{9.5\sqrt{R}}$

- **Capacity:** $C = \frac{1000V}{S}$
- **Length of Transition Curve:**

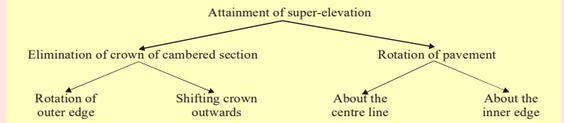
$L_S = \frac{V^3}{C.R}$ $v = m/sec.$ $C = \frac{80}{75+V}$

- **By Rate of introduction of super elevation:**

$L_S = e.N.(w + w_e)$ (Rotation about centre line)

$L_S = \frac{e.N.(w + w_e)}{2}$ (Rotation wrt inner edge

- **By Empirial Formula:** $L_S = \frac{2.7v^2}{R}$ **(Plain & Rolling area),** $L_S = \frac{v^2}{R}$ **(Hilly area)**



(a) If R > 300 m, no extra widening will be required.
(b) On single lane road, it is sufficient to provide mechanical widening only.
(c) For multi-lane roads, the pavement widening may be calculated by adding half the widening for two lane roads to each line.

- **Length of Summit Curve:**

$L = 2S - \frac{4.4}{N}$ **(L<SSD),** $L = \frac{NS^2}{4.4}$ **(L > SSD)**

- **Length of Valley Curve:** $L_S = 2\left(\frac{Nv^3}{C}\right)^{1/2}$ **(Comfort criteria)**

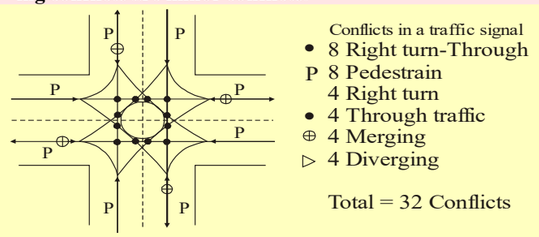
⇒ **L > SSD:** $L = \frac{NS^2}{(2h_1 + 2S\tan\alpha)} = \frac{NS^2}{(1.5 + 0.035S)}$

⇒ **L< SSD:** $L = 2S - \frac{(2h_1 + 2S.\tan\alpha)}{N}$

CIVIL ENGINEERING ROCKET CHART
FOR QUICK REVISION
BY
S.SOROUT: 9255624029

CIVIL BOOSTER - Dnt trust us, Just Check it's content & Then Go for it - (LEAVE THE REST, GET THE BEST) . Available on amazon flipkart. Zero Error book with BEST Content

Crossing conflicts are major conflicts while merging & diverging conflicts are minor conflicts.



Number of potential conflicts:

(*a*) **Both roads are one way = 6**
(*b*) **One road is two way, other one-one way = 11**
(*c*) **Both roads are two way = 24 (Major - 16, Minor - 8)**

Type of Study	Data Collected
Public Transport Inventory study	Available routing and scheduling
Public Transport O–D Study	Starting and destination of riders.
Public Transport operator's study	Vehicle-km, earnings per km usage study.
Public Transport usage study	Passenger Km IVTT, walking time, waiting time.

Traffic Capacity: Maximum no. of vehicles in a lane or a road that can pass a given point in unit time. Expressed in vehicles/ hour/lane.

Types of traffic capacity		
Basic capacity	**Possible capacity**	**Practical capacity**
(Theoretical capacity for nearly ideal roadway & traffic conditions	(Under prevailing conditions) roadway & traffic conditions.	It is also Design capacity It varies from zero to basic capacity.

- **Traffic capacity represents the capability/maximum rate of flow on a road way provided with some level of service characteristics while Traffic volume indicates the actual rate flow and responds to variation in Traffic Demand.**

Presentation of spot speed data
15^{th} percentile speed – Lower limit of speed
85^{th} percentile speed – Safe speed
98^{th} percentile speed – Design speed

Basic Capacity of Single lane, Vehicle Per hours

v = speed kmph, $T(Sec/km) = \frac{3600}{v}$

$q_{max} = \frac{v_f k_j}{4}$

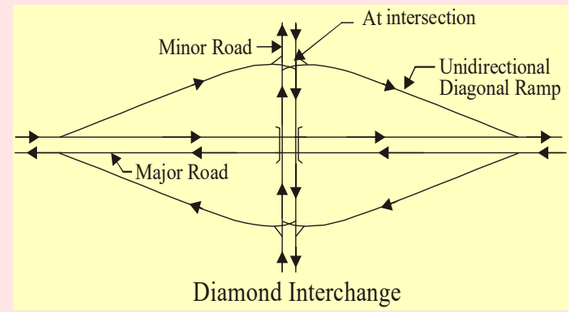
Where
v_f = Free mean speed (Maximum speed at zero density.)
k_j = jam density (Maximum density at zero speed)

- **Maximum flow q_{max} occurs when the speed is $\frac{V_f}{2}$ and density is $k_j/2$.**

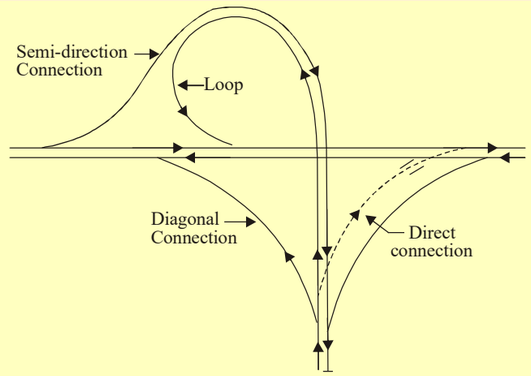
Speed	Application
Space Mean Speed	Traffic flow Studies
Journey Speed	Delay studies
Running Speed	Road conditions Studies
Spot speed	Regulatory measures.

- **Running time excludes stop delayed while total Journey time includes the stop delays.**

Capacity of Rotary ⇒ $\frac{280w\left(1 + \frac{e}{w}\right)\left(1 - \frac{P}{3}\right)}{\left(1 + \frac{w}{l}\right)}$



Diamond Interchange

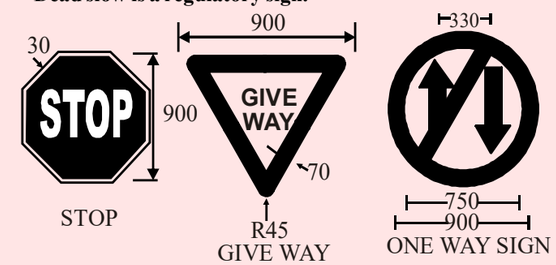


Trumpet Interchange

Classification of traffic Signs

Regulatory/Mandatory	Warning/Cautionary	Informatory
• Give way, stop compulsory left, speed limit etc. • Violation is a legal offence	• Men at work, major road ahead, Hair pin bend etc. • Existence of hazardous conditions.	•Petrol pump, hospital direction sign etc. •For guiding the road user

- **Dead slow is a regulatory sign.**



- **Colour of light used for visibility during fog is yellow.**
- **The length of side of warning sign board of roads is 45 cm.**
- **Road delineators used to provide visual Assistance to drivers about alignment of the road ahead, especially at Night.**
- **Shape of the stop sign according to IRC : 67-2001 is Octogonal.**
- **As per IRC : 67–2001, a Traffic sign indicating the speed limit on a road should be of circular shape with white background and red border.**

- **Indian High ways have coloured milestones:**
  Yellow and white milestones – National highway
  Green and white mildstones – State highway
  Blue/Black and White mildstones–City/Main District road
  Orange and White Milestones – Village road.
- **Trip is defined as the one way movement having single purpose and mode of Travel by a point of origin and a point of destination.**
- **Webster Method**

  Optimum cycle time = $\left(\frac{1.5L+5}{1-y}\right)$
- **Aggregate crushing value:** $\frac{w_2}{w_1}\times 100$
- **Coefficient of Hardness:** $= 20 - \frac{\text{Loss of wt. in gm}}{3}$
- **Rigidity factor:** $R.F = \frac{\text{Contact Pressure}}{\text{Tyre Pressure}}$
- **California Resistance Value:** $t = \frac{k.(T.I)(90-R)}{C^{1/5}}$

Elastic Modulus

- **Δ is maximum vertical deflection of the flexible plate.**

$$\Delta = \frac{1.18p.a}{E_s}$$

- **Rigid circular plate is used instead of flexible.**

$$\Delta = \frac{1.5\,p.a}{E_S}$$

a = radius of plate
p = pressure at deflection
E_s = young's modulus of pavement material.

- **California Bearing Ratio M/D:** $t = \left(\frac{1.75P}{CBR} - \frac{A}{\pi}\right)^{1/2}$

t = Pavement thickness in Cm.
P = wheel load in kg
CBR = California Bearing Ratio (%)
A = Contact Area in cm²

- **CBR TEST:** $CBR = \frac{\text{Load or pressure Substained at 2.5 or 5.0 mm Penetration}}{\text{Load or pressure Substained by standard aggregate at corresponding pressure level.}}$
- **Tri Axial Method:**

$$T_p = \left[\sqrt{\left(\frac{3p.\times y}{2\pi E_S \Delta}\right) - d^2}\right]\left[\frac{E_S}{E_P}\right]^{y_3} \qquad \frac{t_1}{t_2} = \left(\frac{E_2}{E_1}\right)^{1/3}$$

- **Design of Rigid Pavement:** $k = \frac{p}{\Delta} = \frac{P}{0.125}$
- **Radius of Relative Stifiness:** $I = \left[\frac{Eh^3}{12K(1-\mu^2)}\right]^{1/4}$

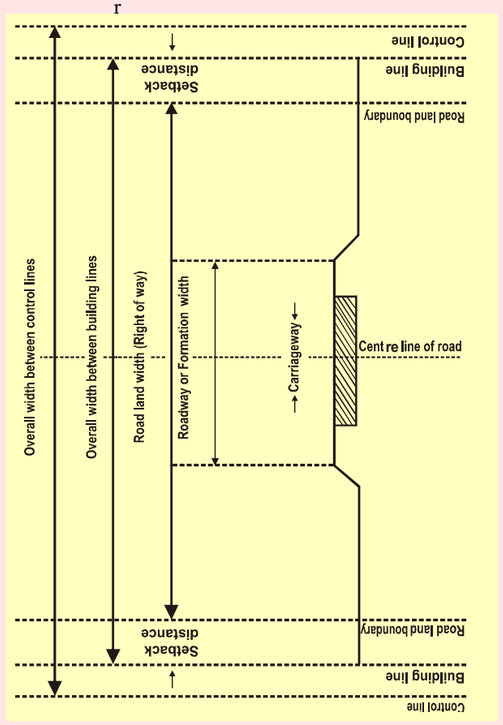
E = Modulus of elasticity of cement concrete pavement kg/cm².
μ = Poission's Ratio, Concrete = 0.15
h = Slab Thickness (cm)
k = Modulus of subgrade reaction (kg/cm³)

Equivalent redius of resisting section

$b = \sqrt{1.6a^2 + h^2} - 0.675h$ **when (a < 1.724 h)**

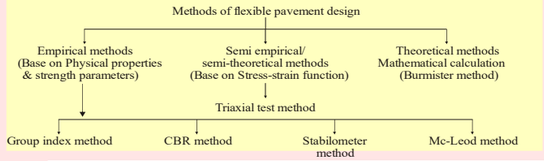
$S_t = \frac{3P}{h^2}$ **(Glodbeck's formula)**

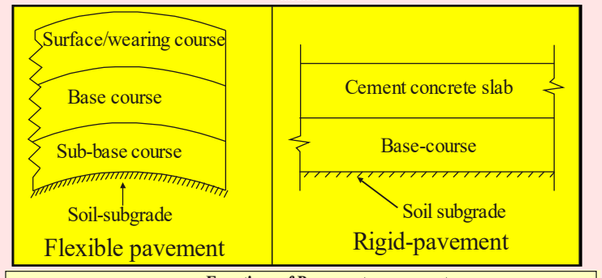
$N = \frac{365A\,[(1+r)^n - 1]}{r} \times F \times D$



Type of Bitumen	Use
Penetration grade 30/40	Areas where temperature difference range is less than 25°C.
Penetration grade 60/70	Superior type of roads with high traffic in normal summer temperature.
Cutback bitumen	Cold weather condition.
Emulsion speed limit	Wet conditions (Rainy season) main-tenance work, soil stabilisation in deserts.

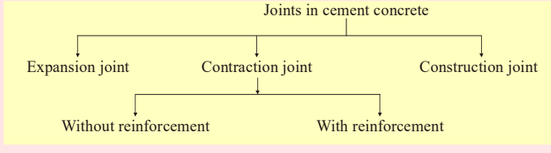
Properties of Bitumen	Type of test	Remark
1. Viscosity	Viscometer test	(i) RC-2, MC-2, SC- 2 having same viscosity but RC-3 is more viscous than RC-2.
2. Specific gravity	Pycnometer test	Specific gravity of pure bitumen is in range of 0.97 to 1.02 but for tar having 1.10 to 1.25
3. Grade of bitumen (hardness of bitumen)	Penetration test	The unit of penetration is 1/10 mm. Industrial bitumen are specified as per IS: 73-1961 as (65/25) meaning softening point & penetration value.
4. Softening point	Ring & ball test	It is the temperature at which bitu men attains a particular degree of softness under standardised test condition.
5. Ductility	Standard briquette of bitumen	Bitumen should be capable of being stretched without breaking (ductility)
6. Purity of Bitumen	Measured by solubility test	A minimum value of 99% is generally suitable with trichloroethlene
7. Consistency of bitumens	Float test	It is a modified viscosity test


Methods of flexible pavement design
Empirical methods (Base on Physical properties & strength parameters)
Semi empirical/ semi-theoretical methods (Base on Stress-strain function)
Theoretical methods Mathematical calculation (Burmister method)
Triaxial test method
Group index method
CBR method
Stabilometer method
Mc-Leod method



Functions of Pavement components			
Soil subgrade	Sub base & base course		Wearing course
• Load is ultimately taken by soil-subgrade. • Top 50 cm layer should be compacted at OMC.	In flexible pavement it improves load carrying capacity.	In rigid pavement it prevents pumping & protects subgrade against frost action.	• To provide a smooth riding surface. Also offer water tightness

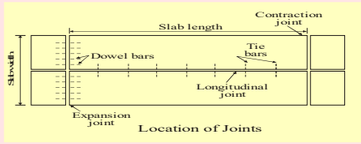
Method of Design	Principle
Group Index Method	Empirical Method using soil Classi-fication Test
CBR Method	Empirical Method using Soil strength Test
US Navy Method	Semi-Theoretical
Asphalt Institute Method	Quasi-rational



Bankelman Beam Deflection Method

Overlay Thickness: $h_0 = 550 \log_{10}\frac{D_c}{D_a}$

Test	Purpose
CBR test	For classifying & evaluating soil subgrade & base course materials for flexible pavements
Crushing test	Strength of Aggregates
Abrasion test	Hardness of Aggregate
Impact test	Toughness of Aggregate
Soundness test	Durability of Aggregate
Shape test	Gives idea of workability & stability of mix
Bitumen Adhesion test	Gives stripping value of Aggregates
Softening point test	It is done by Ring & ball apparatus to ensure safety of Bitumen
Float test	For viscosity of Bitumen.



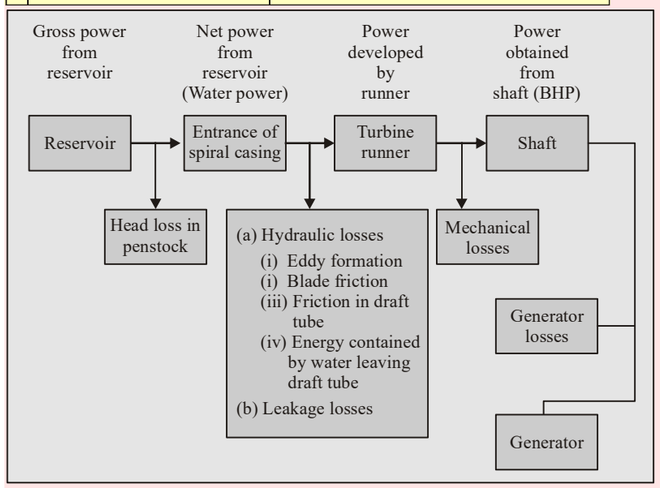
S.SOROUT, 9255624029
FOLLOWING BOOKS AVAILABLE BY
CIVIL Ki GOLI
PUBLICATION:

1. CIVIL Ki GOLI
2. CIVIL BOOSTER
3. REASONING Ki GOLI
4. HARYANA Ki GOLI
5. SOLUTION OF CIVIL Ki GOLI
6. ELECTRICAL & MECHANICAL ENGINEERING ROCKET CHART
7. UTTAR PRADESH Ki GOLI
8. UTTRAKHAND Ki GOLI
9. PUNJAB Ki GOLI
10. WEST BENGAL Ki GOLI
11. HINDI ROCKET CHART
12. CIVIL CAPSULE

Turbine Name	Turbine Type	Type of Energy	N_S (MKS)	Head	Discharge	Direction of flow
Pelton wheel turbine (Single jet)	Impulse	Kinetic	10-35	High (250 to 1000m)	Low(Q<1000 LPM)	Tangential
Peloton wheel turbine (multiple jet)	Impulse	Kinetic	35-60	High (250 to 1000 m)	Low	Tangential flow runner
Francis Turbine	Reaction	Kinetic + Pressure	60-300	Medium (60 to 150 m)	Medium (1000-10000) LPM	Inward Radial Mixed flow (Modern Francis)
Kaplan & Propeller turbine	Reaction	Kinetic + Pressure	300-1000	Low (< 30 m)	High(Q>10000LPM)	Axial flow

Classificationaccording to energy available at input

	Impulse turbine	Reaction Turbine
1.	Input energy is only kinetic energy	1. Input energy is kinetic energy + pressure energy
2.	Pressure remains constant throughout the working & which is equal to atmospheric.	2. pressure drop takes place.
3.	Useful for high head & low discharge	3. Useful for low head & high discharge
4.	Degree of reaction is zero.	4. Degree of reaction not zero.
5.	No draft tube	5. Draft tube is present.
6.	Example Pelton wheel	6. Example (i) Francis Turbine (ii) kaplan & propeller Turbine.



For Reaction Turbine

Turbine	Speed ratio	Flow ratio	No. of vanes
Pelton	0.4–0.5	0	$15+\frac{m}{2}$
Francis	0.6–0.9	0.15–0.3	25 to 30
Kaplan & Propeller	1.8–2.5	0.6–0.9	3 to 8

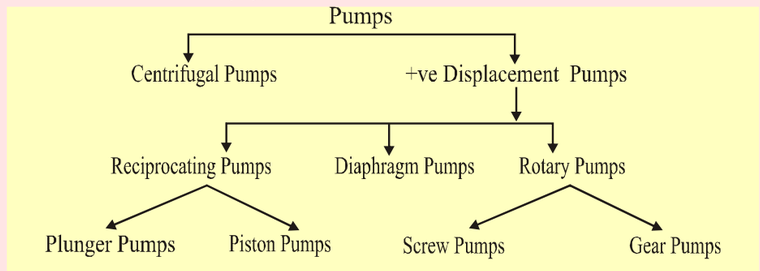
Model Relationship for Turbine

Dimensional Parameter	Diamensionless Parameter
1. $N_S = \frac{N\sqrt{P}}{(H)^{5/4}}$	1. $N_s = \frac{\omega\sqrt{\frac{P}{\rho}}}{(gH)^{5/4}}$
2. $C_Q = \frac{Q}{ND^3}$	2. $C_Q = \frac{Q}{\omega D^3}$
3. $C_H = \frac{H}{N^2D^2}$	3. $C_H = \frac{gh}{\omega^2D^2}$
4. $C_P = \frac{P}{N^3D^5}$	4. $C_P = \frac{P}{\rho\omega^3D^5}$

Here, N_S = Specific speed, C_Q = Discharge coefficient
C_H = Head coefficient, C_P = Power coefficient

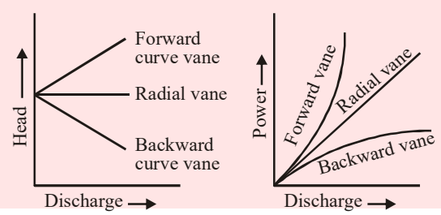
w – Angular speed = $\frac{2\pi N}{60}$, N – No. of revolution/minute

H – Head (m), P – Power



Property	Centrifugal pump	Reciprocating pump
Flow	Continuous and smooth	Fluctuating and pulsating
Maintenance cost	Less	More
Running Speed	Can run at high speed	Cann't run at high speed
Starting torque	More	Less
Wear and Tear	Less	More
Efficiency	Less	More
Floor area	Smaller	Large
Suction and delivery valve	Not necessary	Necessary
Cost	Less	Four times of C.P.
Mechanism	Impeller	Piston
Discharge	High	Low
Priming	Required	Not required
Problem	Cavitation	Water seperation

- **Head Vs discharge and Power Vs discharge realtionship**

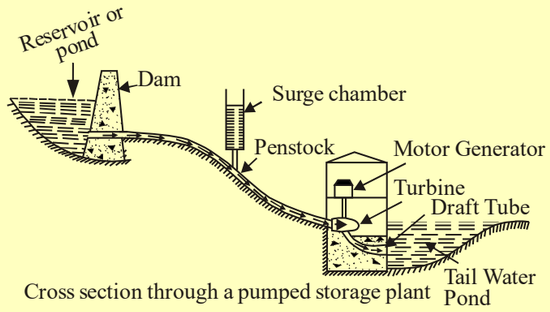


- **Specific speed classification of pumps**

FLOW DIRECTION	SPEED	DIMENSION SPECIFIC SPEED
Radial	Low	10-30
	Medium	30-50
	High	50-80
Mixed Flow		80-160
Axial Flow		160-450

Types of Pump	Range of Head
Low head pump	upto 15m head
Medium head pump	15 m to 40 m
High head pump	above 40 m

- **Specific speed (N_s) = $\frac{N\sqrt{Q}}{(H_m)^{3/4}} = \frac{T^{-1}(L^3T^{-1})^{1/2}}{L^{3/4}} = L^{3/4}T^{-3/2}$**



Cross section through a pumped storage plant

Fluid Path

(a) Pelton (Impulse): Head race (Dam) → Penstock → Nozzle → Bucket (Blades) → Runner → Tail race

(b) Reaction turbine (Kaplan & francis): Head race → Penstock → Casing → Guide vanes → Moving vanes → Runner → Draft tube → Tail race.

- **For turbine** : water power > Runner power > shaft power
- **For pump** : Shaft power > Impeller power > Water power
- **Pumps in series**: Q = Constant, Increase Head, Total $H_m = n\,H_m$
- **Pumps in parallel**: H_m = Constant, Increase discharge, Total Q = n Q
- **Indicator diagram** is the graph between the pressure head in the cylinder & the distance travelled by the piston flow inner dead centre for one complete revolution of the crank, work done by pump is proportional to the area of indicator diagram.
- **Hydraulic RAM** (It work on the principle of water hammer) is a device used to lift small quantity of water to a larger height when a large quantity is available at smaller height. It does not need any external power like electricity.

CIVIL ENGINEERING
ROCKET CHART
FOR QUICK REVISION
CIVIL BOOSTER - Dnt trust us, Just Check it's content & Then Go for it - (LEAVE THE REST, GET THE BEST) . Available on amazon flipkart. Zero Error book with BEST Content

Some specific fluid properties

1. **Density** = $\frac{\text{mass}}{\text{volume}}$ **(measured in kg/m³).**
2. **Density of liquid & gas is directly proportional to pressure and inversely to temperature**
3. **Specific gravity/relative density**

$$= \frac{\text{Density of liquid}}{\text{Density of water at 4°C}}$$

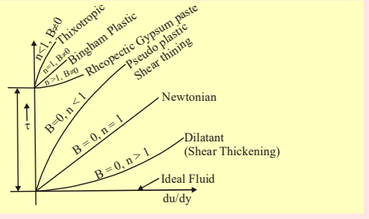
4. **If R.D < 1, then fluid is lighter than water.**
5. **Specific weight** = $\frac{\text{Weight of substance}}{\text{Volume of substance}}$, **($\gamma = \rho g$ in N/m³)**
6. **Some Important Relation**

1 milibar = 10^{-3} bar =100 N/m²
1 mm of Hg = 10^{-3} m of Hg = 10^{-3} × 13.6 m of water = 10^{-3} × 13.6 × 9810 N/m² = 133.42 N/m²
1 N/mm² = 10^6 N/m²

1 Kgf/cm² = $\frac{9.81\text{ N}}{10^{-4}\text{ m}^2}$ **= 98.1 × 10^3 N/m²**

7. $\gamma_{water} = 9810\frac{N}{m^3} = 9.81\frac{KN}{m^3}$
8. $\gamma_{mercury} = 13.6\,\gamma_w$
9. **Specific volume** = $\frac{1}{\text{Density}}$

- **Viscosity:** $\mu = \frac{\tau}{\frac{d\theta}{dt}}$ $\frac{d\theta}{dt} = \frac{du}{dy}$
- **Kinematic Visocity:** $V = \frac{\mu}{\rho}$ **m²/sec.**
- **Newton's Law Of Viscosity:** $\tau = \mu\frac{du}{dy}$
- **Non- Newtonian Fluid:** $\tau = A\left(\frac{du}{dy}\right)^n + B$



- **Ex.**
  - (a) Thixotropic — Ink, Ketchup, Enamels etc.
  - (b) Bingham plastic — Sewage, Sludge, Drilling mud, Gel, Toothpaste, Cream
  - (c) Rheopectic — Gypsum in water & Bentonite slurry.
  - (d) Pseudo Plastic — Paint, Paper, Pulp, Blood, Syrup, Polymer, Lipstick, Nailpaint
  - (e) Dilatant — Quick sand, Sugar in water, Butter

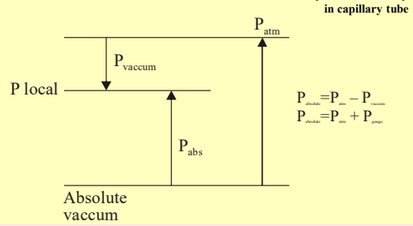
CIVIL ENGINEERING ROCKET CHART
FOR QUICK REVISION

Note :

1. **Wetting property is due to surface tension.**
2. **Higher temperature, more chances of cavitation.**
3. **At 100°C, vapour pressure of water = Atmospheric pressure.**
4. **Air cavitation is less damaging than vapour cavitation.**
5. **Ideal fluids → No-viscosity → no "No slip" condition**
6. **No slip condition is due to fluid viscosity.**

- **Pressure Inside The Liquid Drop:** $P_{ld} = \frac{4\sigma}{d}$
- **Pressure Inside The Liquid Jet:** $P_{lj} = \frac{2\sigma}{d}$
- **Pressure Inside the Soap Bubble:** $P_{sb} = \frac{8\sigma}{d}$
- **Expression For Capillary Rise:** $h = \frac{4\sigma\cos\theta}{wd}$

ϕ < 90° Cohesion < Adhesion Wetting of surface Concave top surface Rise in capillary tube
ϕ > 90° Adhesion < cohesion Does not wets the Convex top surface Drop in capillary tube



Note :

- **Buoyant force is independent of distance of body from free surface of liquid and also the density of solid body.**
- **Mechanical gauges are used for measuring high pressure values which does not requires high precision.**
- **Air cavitation is less damaging than vapour cavitation.**

Facts about pressure

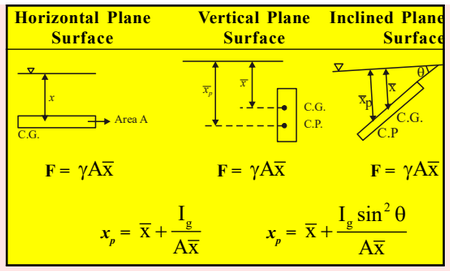
1. **Longer runway's needed at higher altitude due to reduced drag and lift.**
2. **Nose bleeding starts at higher altitude due to difference in body's blood pressure & atmosphere pressure.**
3. **Motor capacity reduces at higher altitude.**
4. **Cooking takes longer time at higher altitudes.**

- **Buoyancy And Floatation**

Buoyant force = Net upward force = weight of liquid displaced

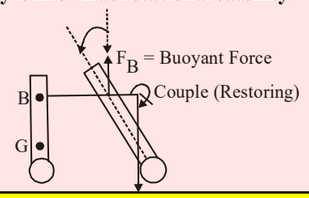
- **Point of application of buoyant force is the C.G. of the displaced liquid & it is called centre of buoyancy.**
  - **Buoyant force is independent of distance of body from free surface of liquid and also the density of solid body.**

CIVIL BOOSTER - Dnt trust us, Just Check it's content & Then Go for it - (LEAVE THE REST, GET THE BEST) . Available on amazon flipkart.



$\bar{x}$ & $\bar{x}_p$ for same horizontal plane surface from liquid surface

Rotational Stability: When a small angular displacement sets up a restoring couple, then stability is known as rotational stability.



Submerged body	Floating body
Stable equilibrium G below B	**M above G, BM > BG**
	GM = MB – BG = +Ve
Unstable equilibrium G above B	**M below G, BM < MG**
	GM = MB – BG = –Ve
Neutral equilibrium G and B coincide	**GM = 0**

Metacentre (M) is the point of intersection of lines of action of buoyant force before and after rotation.

- **Continuity Equation:** $A_1V_1 = A_2V_2$
- **Hydrostatic Force**

Horizontal $F = WA\bar{x}$ $h = \bar{x}$

Vertical $F = WA\bar{x}$ $h = \bar{x} + \frac{I_g}{A\bar{x}}$

Inclined $F = WA\bar{x}$ $h = \bar{x} + \frac{Ig}{Ax}\sin^2\theta$

Note: We generally follow Eulerian concept, as its difficult to keep the track of a single fluid particle.

Types of fluid :

1. **Steady and Unsteady Flow: At any given location, the flow and fluid properties do not change with time, then its steady flow otherwise unsteady.**

$$\frac{\partial v}{\partial t} = 0,\ \frac{\partial p}{\partial t} = 0,\ \frac{\partial f}{\partial t} = 0 \Rightarrow \text{Steady flow}$$

2. **Uniform and Non-Uniform Flow: A flow is said to be uniform flow in which velocity & flow both in magnitude and direction do not change along the direction of flow for given instant of time.**
3. **One, two or three Dimensional Flow: If flow parameters varies in one dimension wrt space only then its one dimensional otherwise its 2 or 3 dimension respectively.**
   - **V = V(x, t) → one dimensional**
   - **V = V(x, y, t) → two dimensional**
   - **V = V(x, y, z, t) → three dimensional**
4. **Laminar and Turbulent Flow: In Laminar flow, the particles moves in layers sliding smoothly over the adjacent layers while in turbulent flow particles have the random and erratic movement, intermixing in the adjacent layers. Which causes continuous momentum transfer. Flow of blood in veins and arteries occurs as a viscous flow. Hence, Laminar flow. A water supply pipe carries water at high speed leading to rapid mixing which causes highly turbulent conditions.**
5. **Rotational and Irrotational Flow: When fluid particles rotate about their mass centre during movement. Flow is said to be rotational otherwise irrotational. Rotational Flow → Forced Vortex, Flow inside boundary layer. Irrotational Flow → Free Vortex, Flow outside boundary layer. In a straight tube of uniform diameter and uniform roughness, the flow properties does not vary across the length of the pipe. Hence, Uniform flow. Flow above the drain having a wash basin is a free vortex motion (Irrotational flow).**
6. **Compressible and Incompressible Flow: In compressible flow density of fluid changes from time to time while in Incompressible flow it remains constant.**

- **Stream Line: There are a set of concentric circle with origin at centre.**
- **Stream lines neither touch nor cross each other. Line tangent to it give direction of Instantaneous velocity.**
- **Tracing of motion of different fluid particle.** $\frac{dx}{u} = \frac{dy}{v} = \frac{dz}{w}$ **Equation of stream line**
- **Streak Line: It is line traced by series of fluid particles passing through a fixed point. It is formed by continous introduction of dye or smoke from a point in the flow.**
- **Path Lines: It is actual path traced by a fluid particle over a period of time. It is based on lagrangian concept. Two path lines can intersect each other.**

Continuity Equation: It is based on principle of conservation of mass. Fluid mass can neither be created nor can be destroyed hence mass of fluid entering a fixed region should be equal to mass of fluid leaving that fixed region in a particular time.

(a) Steady Flow in 1-D, ρAV = Constant

$$\rho_1A_1V_1 = \rho_2A_2V_2$$

(b) Steady Incompressible in 1-D,

$$A_1V_1 = A_2V_2$$

Total Acceleration = Convective acceleration with respect to space + local acceleration with respect to time.

Type of flow	Convective Acceleration	Temporal Acceleration
Steady & uniform	0	0
Steady & non-uniform	Exists	0
Unsteady & uniform	0	Exists
Unsteady & non-uniform	Exists	Exists

Measurement of fluid pressure

Manometer
Based on principle of balancing a column of fluid by the same or other column

Mechanical gauges
Mechanical pressure measuring instruments with a deflecting needle (used in filling air in tyres)

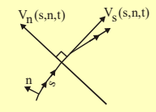
Simple manometer
To measure pressure at a point
- U-Tube manometer
- Single column manometer
- Piezometer

Differential manometer
To measure the pressure difference
- Inverted differential manometer
- Micro manometer

No.	Type of Manometer	Fluid Types	Pressure measurement
1.	Piezometer	Liquid	Positive (Gauge pressure)
2.	U-tube Manometer	Both liquid & gases	Both positive & Negative Pressure
3.	Inclined Tube Manometer	Gases (for very low pressure)	Both (+ve & -ve) (mostly +ve)
4.	Differential & Inverted Differential	Both liquid & gases	Pressure difference Between 2 points
5.	Bourdon Pressure gauge	Both liquid & gases	It measures pressure at a point

Acceleration on a stream line

Trangential Acceleration It is due to change in magnitude of velocity. If spacing b/w stream line changes tangensial acceleration exists



Normal Acceleration It is due to the change in the direction of fluid moving on a curved path

- **Acceleration Of A Fluid Particle**

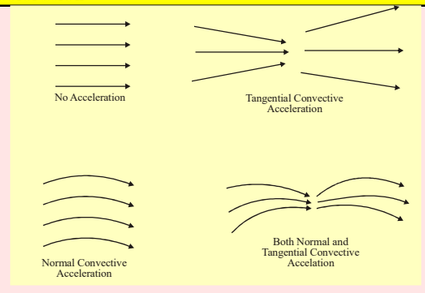
$$a_x = \underbrace{\frac{u\partial u}{\partial x} + \frac{v\partial u}{\partial y} + \frac{w\partial u}{\partial z}}_{\text{Convective acceleration}} + \underbrace{\frac{\partial u}{\partial t}}_{\text{Temporal acceleration}}$$

$$a_s = V_s\frac{\partial v_s}{\partial s} + \frac{\partial v_s}{\partial t}$$

convective tangential acceleration **local tangential acceleration**

$$a_n = V_s\frac{\partial v_n}{\partial s} + \frac{\partial v_s}{\partial t}$$

convective normal acceleration **local normal**



- **Rotational Component**

$$w_x = \frac{1}{2}\left(\frac{\partial w}{dy} - \frac{\partial v}{dz}\right), \quad w_z = \frac{1}{2}\left(\frac{\partial v}{\partial x} - \frac{\partial u}{\partial y}\right), \quad w_y = \frac{1}{2}\left(\frac{\partial u}{\partial z} - \frac{\partial w}{\partial x}\right)$$

Note :

1. **Velocity potential exists only for ideal and irrotational flow.**
2. **Velocity of flow is in direction of decreasing potential function.**
3. **Equipotential line is the line joining points having same potential function.**

- **Velocity Potential Function (ϕ):**

$$-\frac{\partial \phi}{\partial x} = u \qquad -\frac{\partial \phi}{\partial y} = v$$

- **Stream Function (v):** $u = -\frac{\partial \psi}{\partial y}$ $\quad v = \frac{\partial \psi}{\partial x}$

(*i*)Newton's equation of motion

$$\vec{F_g} + \vec{F_p} + \vec{F_V} + \vec{F_t} + \vec{F_e} + \vec{F_\sigma} = m\vec{a}$$

(*ii*) Reynold's equation of motion

$$\vec{F_g} + \vec{F_p} + \vec{F_V} + \vec{F_t} = m\vec{a}$$

(*iii*) Navier-stock equation of motion

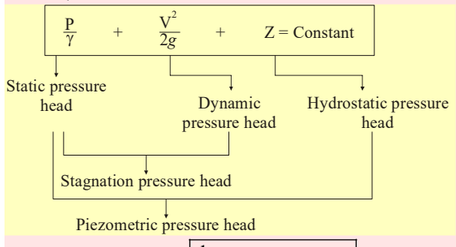
$$\vec{F_g} + \vec{F_p} + \vec{F_V} = m\vec{a}$$

(*iv*) Euler's equation of motion

$$\vec{F_g} + \vec{F_p} = m\vec{a}$$

Note :

- **Energy equation can be used to find the pressure at a point in a pipeline using Bernoulli's eq.**
- **Continuity eq. is used to find out the flow at two sections of tapering pipes.**
- **Euler equation based on momentum conservation while Bernoulli is based on energy conservation.**
- **Impulse momentum principle is used to find out the force on a moving vane.**
- **Concept of moment of momentum (Angular momentum principle is used in lawn sprinkler problems)**



- **Euler's Equation:** $\frac{dp}{p} + gdz + vdv = 0$
- **Bernoullies Equation:** $\frac{P}{w} + z + \frac{v^2}{2g}$ **= constant.**
- **Rotameter is used to measure discharge while current meter is used to measure velocity in open channel.**
- **Hot Wire Anemometer: Used for measurement of Instantaneous velocity and temperature at a point in flow.**
- **Theoretical Discharge:**

$$Q_{th} = \frac{A_1 A_2 \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}} \qquad C_d = \frac{qA_{ct}}{q_{th}} = \sqrt{\frac{h - h_L}{h}}$$

- **Percentage Error In Discharge:**

$$\%\ \text{error} = \frac{Q_{th} - Q_{act}}{Q_{th}} \times 100$$

$$\%\ \text{error} = (1 - C_d) \times 100$$

NOTE.
When Pressure Difference Measured by Manometer
When heavier fluid in manometer & lighter fluid in pipe.

$$h = x\left(\frac{g_h}{g_l} - 1\right)$$

$g_h \rightarrow$ Specific gravity of heavier liquid
$g_l \rightarrow$ Specific gravity of lighter liquid
$x \rightarrow$ Reading Manometer
$h \rightarrow$ Reading Piezometer.

- **Orificemeter:**

$$\theta = \frac{Cd_0\, A_1 A_0 \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}} \qquad C_C = \frac{A_C}{A_0} \qquad C_d = C_c \times C_v$$

Where
$C_c \rightarrow$ Coefficient of Contraction.
$C_d \rightarrow$ Coefficient of Discharge
$C_V \rightarrow$ Coefficient of Velocity.

- **Pitot Tube –Velocity Of Flow:**

$$\frac{P_1}{w} + \frac{V_1^2}{2g} = \text{Constant}$$

- **Reynold's Number:** $R_e = \frac{\rho v d}{\mu}$

Nature of flow according to Reynold's number (R_e)

	Laminar	Transition	Turbulent
Flow in pipe	$R_e < 2000$	$2000 < R_e < 4000$	$R_e > 4000$
Flow between parallel plate	$R_e < 1000$	$1000 < R_e < 2000$	$R_e > 2000$
Open channel flow	$R_e < 500$	$500 < R_e < 2000$	$R_e > 2000$
Flow through soil	$R_e < 1$	$1 < R_e < 2$	$R_e > 2$

- **Laminar Flow Through Circular Pipe:**

$$\tau = -\frac{r}{2}\left(\frac{dp}{dx}\right)$$

- **Velocity Distribution:**

$$U_{max} = -\frac{1}{4\mu}\left(\frac{\partial p}{\partial x}\right)R^2 \qquad U = U_{max}\left(1 - \frac{r^2}{R^2}\right)$$

- **Discharge:** $Q = \frac{\pi U_{max} R^2}{2}$ $\quad Q = \frac{\pi}{128\mu}\left(-\frac{\partial P}{\partial x}\right)D^4$
- **Friction Factor:** $F = 4f$ $\quad f = \frac{16}{R_e}$ $\quad f = \frac{8\tau_0}{\rho u^2}$
- **Trapezoidal Notch:**

$$Q = \frac{2}{3}C_{d_1}\sqrt{2g}LH^{3/2} + \frac{8}{15}C_{d_2}\sqrt{2g}\tan\frac{\theta}{2}H^{5/2}$$

Cipolletti-Weir: It is a trapezoidal weir whose slopes are adjusted in such a way that:

- **Reduction in discharge due to end contraction in rectangular weir = Increase in discharge due to triangular portion.**
- **Entrance length in a pipe is the length where boundary layer increases and flow is fully developed.**
  For Laminar Flow $L = 0.07\, R_e\, D$
  For Turbulent Flow $L_e = 50\, D$
- **Major Losses Head/Loses**

$$h_L = \frac{fLQ^2}{12D^5} \qquad h_f = \frac{fLv^2}{2gD}$$

Number	Equation	Uses
Reynolds No.	$\frac{F_i}{F_v} = \frac{\rho VL}{\mu}$	Aeroplanes, submarines, pipe flow
Eulers No.	$\sqrt{\frac{F_i}{F_p}} = \frac{V}{\sqrt{\frac{p}{\rho}}}$	Cavitation problem
Mach No.	$\sqrt{\frac{F_i}{F_e}} = \frac{V}{C}$	Aerodynamic testing, rocket, missile
Froude No.	$\sqrt{\frac{F_i}{F_g}} = \frac{V}{\sqrt{gL}}$	OCF, spillway, weir
Weber No.	$\sqrt{\frac{F_i}{F_\sigma}} = \frac{v}{\sqrt{\sigma/\rho L}}$	Veins, arteries, rising bubble

Water hammer Pressure: Rapid/Sudden closure of valve in a pipe carying flowing liquid destroys the momentum of flowing liquid and sets up a high pressure wave. This pressure wave travels with the speed of sound and causes hammering action in pipe called Knocking water hammer.

- **Surge tanks are used to absorb the Increase in the pressure due to water hammer phenomenon.**

Chezy's Formula: $V = C\sqrt{RS}$,

Manning equation $V = \frac{1}{n}R^{2/3}S_0^{1/2}$

Dimension of C = $L^{1/2}\,T^{-1}$, n = $L^{-1/3}\,T^1$, f = Dimensionless

Dynamic eq. for G.V.F.: $\frac{dy}{dx} = \left(\frac{S_o - S_f}{1 - \frac{q^2}{gy^3}}\right)$

Hydraulic Jump Eq.

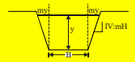
1. $\frac{2q^2}{g} = y_1 y_2 (y_1 + y_2)$ 2. Energy Loss $E_L = \frac{(y_2 - y_1)^3}{4y_1 y_2}$

3. $\frac{y_2}{y_1} = \frac{1}{2}\left(\sqrt{1 + 8F_1^2} - 1\right)$ 4. $y_c^3 = \frac{y_1 y_2 (y_1 + y_2)}{2}$

Open-channel Flow						
Steady				unsteady		
Uniform Canal Flow	Gradually Varied (GVF)	Rapidly Varied (RVF)	Spatially Varied (SVF)	Gradually Varied (GVUF)	Rapidly Varied (RVUF)	Spatially Varied (SVUF)
Flow in river U/S of a weir during winter		Flow D/S of an overflow spillway.	Flow over side weir	River Flow in alluvial reach during rising flood	A surge moving upstream	Surface runoff due to rainfall

Type of flow	Depth of	Velocity of flow	Froude flow	Comments No
Subcritical	$y > y_c$	$v < v_c$	$F_r < 1$	Also called as streaming or transquil flow
Critical	$y = y_c$	$v = v_c$	$F_r = 1$	
Super Critical	$y < y_c$	$v > v_c$	$F_r > 1$	Shooting flow, rapid flow, torrential flow

Chart for Most Economical Sections

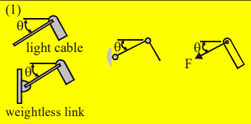
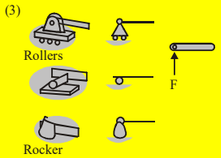
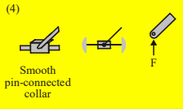
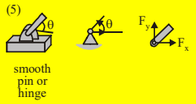
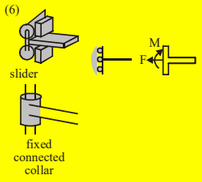
Gedmetrical Parameters	Rectangular	Triangular	Trapezoidal
Diagram			
Condition	$y = \frac{B}{2}$	m = 1, q = 45°→From Horizontal	
for most Economical		θ = 45° → From vertical	$B = \frac{2y}{\sqrt{3}}$, $m = \frac{1}{\sqrt{3}}$ θ = 60° Hor., θ = 30° vert.
Area	A = B.y = 2y.y	$A = my^2$	$A = (B + my) \times y$
	$A = 2y^2$ (in most economical) θ = 2y	$A = y^2$ (in most economical) m = 1	$A = \left(\frac{2y}{\sqrt{3}} + \frac{1}{\sqrt{3}}y\right)y = \left(\sqrt{3}\right)y^2$
Perimeter	$P = 4y$	$p = 2\sqrt{2}y$	$P = 2\sqrt{3}y$
Hydraullic Radius (R = A/P)	$R = y/2$	$R = \frac{y^2}{2\sqrt{2}y}$	$R = \frac{y}{2}$
Top width (T)	$T = 2y$	$T = 2y$	$T = \frac{4y}{\sqrt{3}}$
Hydraullic Depth $\left(D = \frac{A}{T}\right)$	$D = y$	$D = y/2$	$D = \frac{3}{4}y$

Note: Circular section (a) For maximum discharge 2θ = 302°22′, d ≃ 0.95 D, (b) For maximum velocity 2θ = 257°27′, d = 0.81 D

Types of Jump	Fr	E_L/E_1	Water surface
Undular	1-1.7	≈ 0	Undulating
Weak	1.7-2.5	5–18%	Small rollers form
Oscillating	2.5-4.5	18–45%	Water oscillates in random manner
Steady	4.5-9	45–70%	Roller and jump action
strong	≥ 9	≥ 70%	Very rough and choppy

$N_S = \frac{N\sqrt{P}}{(H)^{5/4}}$ **(for Turbine),** $N_S = \frac{N\sqrt{Q}}{(H_m)^{3/4}}$ **(for Pump)**

S.SOROUT, 9255624029
FOLLOWING BOOKS AVAILABLE BY
CIVIL Ki GOLI
PUBLICATION:
1. CIVIL Ki GOLI
2. CIVIL BOOSTER
3. REASONING Ki GOLI
4. HARYANA Ki GOLI
5. SOLUTION OF CIVIL Ki GOLI
6. ELECTRICAL & MECHANICAL ENGINEERING ROCKET CHART
7. UTTAR PRADESH Ki GOLI
8. UTTRAKHAND Ki GOLI
9. PUNJAB Ki GOLI
10. WEST BENGAL Ki GOLI
11. HINDI ROCKET CHART
12. CIVIL CAPSULE

Type of connection	Idealized symbol	Reaction of constraints	Number of unknowns/ constraints One Unknown.
(1) light cable, weightless link			The reaction is a force that acts in the direction of the cable or link
(2) smooth contacting surface			One unknown. The reaction is a force that acts per-pendicular to the surface at the point of contact.
(3) Rollers, Rocker			One Unknown The reaction is a force that acts per-pendicular to the surface at the point of contact.
(4) Smooth pin-connected collar			One unknown. The reaction is a force that acts per-pendicular to the surface at the point of contact.
(5) smooth pin or hinge			Two unknowns. The reaction are two force components
(6) slider, fixed connected collar			Two unknowns. The reaction are a force & a moment.
(7)			Three unknowns. The reaction are the moment & the two force

Static Inteterminancy:

$$D_S = D_{SE} + D_{Si}$$

No. of additional reactions reuired to analyse a structure is called static indeterminancy.

- **D_s for 2D truss : $m + r_e - 2j$**
- **D_s for 3D truss : $m + r_e - 3j$**
- **D_s for 2D rigid frames : $D_s = 3C - r'$**
  where C – no. of cuts required to produce open stable tree like structure
  r′ – no. of retraints added to make structure perfectly rigid
- **D_s for 3D rigid frames: $D_s = 6C - r'$**

D_s for beam, $D_s = D_{se} + D_{si}$, $D_s = r - s$ (because beam have $D_{si} = 0$)

Kinematic Indeterminancy:

Refers to degree of freedom at all joint.

- **For 2D rigid frames:**

$$D_k = 3j - r_e + r_r - n_r$$

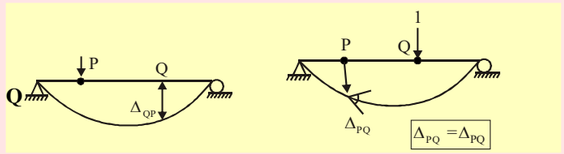
- **For 3D rigid frames:**

$$D_k = 6j - r_e + r_r - n_r$$

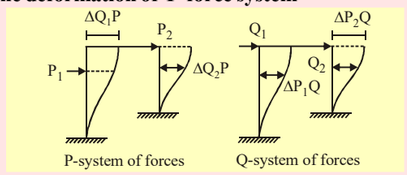
Where j → no. of joints.
r_e → reactions released
r_r → reactions available at supports.
n_r → no. of members axially rigid.

Maxwell's reciprocal theorem: It is a special cases of Bettis law. If only two froce P & Q are acting & magnitude of P and Q are unity, then $\Delta_{PQ} = \Delta_{QP}$ where, Δ_{QP} = Deflection at Q due to unit load at P

Δ_{PQ} = Deflection at P due to unit load at



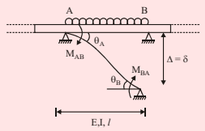
Betti's Theorem: In it, the virtual work done by a P-force system in going through deformation of Q - Force system is equal to the virtual work done by the Q-force system in going through the deformation of P-force system



$$P_1\Delta P_1 Q + P_2\Delta P_2 Q = Q_1\Delta Q_1 P + Q_2\Delta Q_2 P$$

Castigliano's 1st theorem	Castigliano's 2nd theorem
(a) The first partial derivative of total internal energy (strain energy) in a structure with respect to any particular deflection component at a point is equal to the force applied at that point & in the direction corresponding to the deflection component. $\frac{\partial U}{\partial \delta} = P$ or $\frac{\partial U}{\partial \theta} = M$	(a) The first partial derivative of total internal energy in a structure with respect to the force applied at any point is equal to the deflection at the point of application of that force in the direction of its line of action. $\frac{\partial U}{\partial P} = \delta$ or $\frac{\partial U}{\partial M} = \theta$
(b) Castigliano's 1st theorem is applicable to linearly or non-linearly elastic structures in which the temperature is constant & the supports are unyilding.	(b) Castigliano's 2nd theorem is applicable to linearly elastic (Hookean material structures with constant temperature & unyielding supports.

1. Continuous Beam



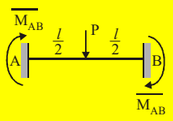
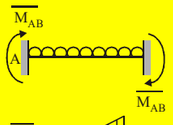
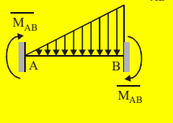
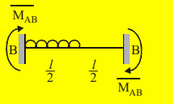
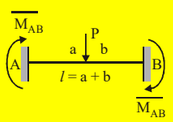
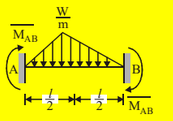
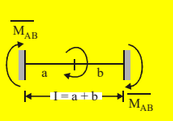
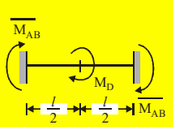
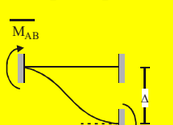
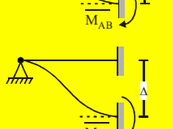
$$M_{AB} = M_{FAB} + \frac{2EI}{l}\left(2\theta_A + \theta_B - \frac{3\delta}{l}\right)$$

$$M_{BA} = M_{FBA} + \frac{2EI}{l}\left(2\theta_B + \theta_A - \frac{3\delta}{l}\right)$$

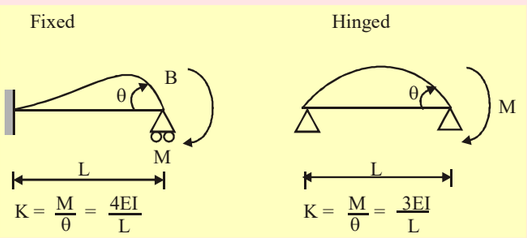
2. When one end is pin supported

$$M_{AB} = M_{FAB} - \frac{M_{FBA}}{2} + \frac{3EI}{L}\left(\theta_A - \frac{\delta}{L}\right)$$

Fixed end Moments.

Loading Diagram	M_{AB}	M_{BA}
	$\frac{-Pl}{8}$	$\frac{Pl}{8}$
	$\frac{-Wl^2}{12}$	$\frac{Wl^2}{12}$
	$\frac{-Wl^2}{30}$	$\frac{Wl^2}{20}$
	$\frac{-11}{192}Wl^2$	$\frac{5}{192}Wl^2$
	$\frac{-Pab^2}{l^2}$	$\frac{Pa^2b}{l^2}$
	$\frac{-5}{96}Wl^2$	$\frac{5}{96}Wl^2$
	$\frac{M_o b(2a-b)}{L^2}$	$\frac{M_o a(2b-a)}{L^2}$
	$\frac{M_D}{4}$	$\frac{M_D}{4}$
	$\frac{-6EI\Delta}{l^2}$	$\frac{-6EI\Delta}{l^2}$
	0	$\frac{-3EI\Delta}{l^2}$

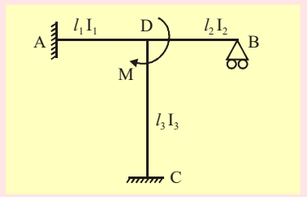
Member Stiffness: Stiffness of a member AB when farther end is



Joint Stiffness Factor: Considering joint 'D' to be rigidly connected Applying moment 'M' at D

$M = M_1 + M_2 + M_3$; $M = K_1\theta + K_2\theta + K_3\theta$

$$K = \frac{M}{\theta} = K_1 + K_2 + K_3 + = \frac{4EI_1}{\iota_1} + \frac{3EI_2}{\iota_2} + \frac{4EI_3}{\iota_3}$$



Distribution Factor (D.F.):

Sum of DF for all members at a joint is always one

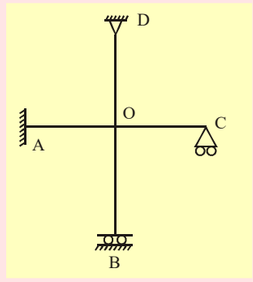
$$DF = \frac{\text{Stiffness of a member}}{\text{Sum of stiffness of all members at that joint}}$$

$$DF = \frac{\text{Relative stiffness of a member}}{\text{Sum of Relative stiffness of all members at that joint}}$$

Relative stiffness

(a) when far end is fixed = I / l

(b) when far end is hinged = $\frac{3I}{4l}$



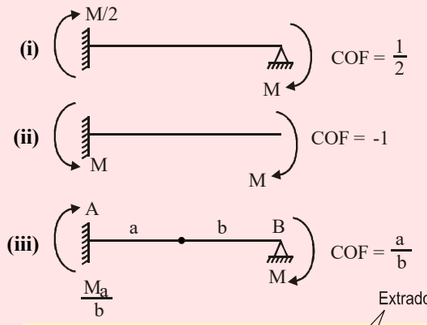
CIVIL ENGINEERING ROCKET CHART
FOR QUICK REVISION
BY
S.SOROUT: 9255624029

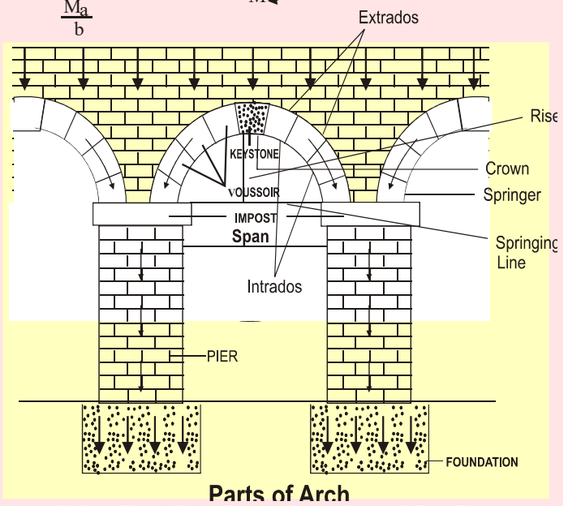
CIVIL BOOSTER - Dnt trust us, Just Check it's content & Then Go for it - (LEAVE THE REST, GET THE BEST) . Available on amazon flipkart. Zero Error book with BEST Content

Carry Over Factor = (COF)

$$COF = \frac{\text{Carry over moment}}{\text{Applied moment}}$$

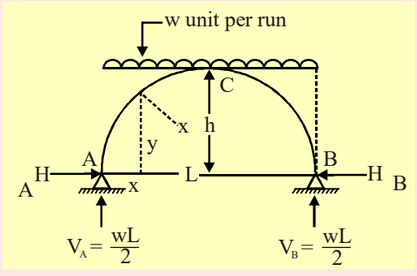
Standard Cases





Parts of Arch

- **An arch is subjected to thrust, shear force & bending moment.**
- **A three hinged arch is subjected to normal thrust & radial shear and bending moment.**
- **A linear arch is subjected to normal thrust only.**



Profile, $y = \frac{4h}{l^2}x(l-x)$

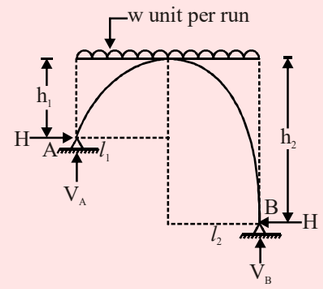
$$H_A = H_B = \frac{wl^2}{8h};\ V_A = V_B = \frac{WL}{2}$$

Moment at only section × from A – $M_x = V_A x - \frac{Wx^2}{2} - Hy$

$M_x = 0$

Where, H_A = Horizontal thrust = H_B

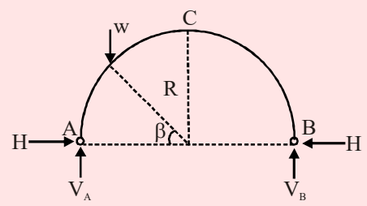
V_A = Vertical reaction at A = $\frac{wl}{2} = V_B$.



$$l_1 = \frac{l\sqrt{h_1}}{\sqrt{h_1}+\sqrt{h_2}};\quad l_2 = \frac{l\sqrt{h_2}}{\sqrt{h_1}+\sqrt{h_2}}$$

$$H_A = H_B = \frac{wl^2}{2\left(\sqrt{h_1}+\sqrt{h_2}\right)^2}$$

$$H_A = H_B = \frac{w}{\pi}\sin^2\beta \quad \text{(At crown } \alpha = 90^\circ,\ H = \frac{w}{\pi}\text{)}$$



Various types of Arches :

A drop arch is pointed with a span greater than its radii.

Two centered arch - The curve surface of these arches makes from two center points. Examples of two centered arches equilateral, pointed lancet and Venetian arches.

A lancet arch is pointed, with radii much larger than the span.

Three Centred arch - The curve surface of these arches is made from three center points. This arch is the more or less semi-elliptical arch. Ex. -Ogee arch, Drop arch, Semi-elliptical arch

An ogee arch is pointed and usually of four arcs, the centers of two inside the arch & two outside; this produces a compound curve . It is also called as keel arch.

Methods of Analysis of statically determinate truss

Method of joint	Method of section
$\Sigma F_x = 0,\ \Sigma F_y = 0$ Analysis should start at joint having atleast one known force & at most two unknown forces.	It is used for solving the unknown force acting on the members of a truss. The method involved breaking the truss down into individual sections and analyzing each section as a separate rigid body

Note : Pratt truss is better than Howe truss as the diagonal member in Pratt truss carries tension but in Howe truss, diagonal member carries compression. If longer member carries compression, there is likely chance of buckling of truss member.

King post truss – The spacing of the king post truss is limited to 3m centre to centre. The truss is suitable for spans varying from 5 - 8 meters.

Queen post truss – This truss differs from a king post truss having two vertical post, known as queen posts. This truss is suitable for 8-12m spans.

Fink Truss – It is used for longer span having high pitch roof. The web members in such truss are Sub-divided to obtain shorter members.

Howe Truss – This type of truss is a combination of steel & wood, which makes it elegant, while also offering a very appealing design. It has a very wide span, as it can cover anything from 6-30m.

Zero-force Members:

1. **If three members join at a point & out of them, two are collinear & also no external load acts at joint, the third member is a zero force member.**
2. **If only two non-collinear members exist at a truss joint & no external force or support reaction is applied to the joint, the members must be zero force member.**

Deflection of Truss joint

1. **Castigliano's Method**

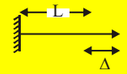
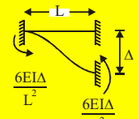
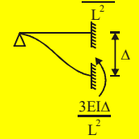
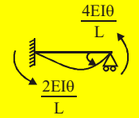
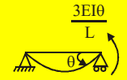
$$\Delta = \frac{\partial U}{\partial F}$$

$$U = \sum_{i=1}^{n}\frac{P_i^2 dx}{2AE} \qquad so\ \Delta = \frac{\partial}{\partial F}\left(\sum_{i=1}^{n}\frac{P_i^2 dx}{2AE}\right)$$

2. **Maxwell's unit load method**

External virtual work = Internal vitual wrok

$$1\times\Delta = \sum u_i\left(\frac{P_i dx}{A_i E_i} + l_i\,\alpha_i\Delta t_i + \lambda_i\right)$$

Type of displacement	Diagram	Flexibility	Stiffness
(i) Axial displacement		$\frac{L}{AE}$	$\frac{AE}{L}$
(ii) Transverse displacement		$\frac{L^3}{12EI}$	$\frac{12EI}{L^3}$
(a) With far end hinged		$\frac{L^3}{3EI}$	$\frac{3EI\Delta}{L^3}$
(iii) Torsional displacement		$\frac{L}{GI_p}$	$\frac{GI_p}{L}$
(iv) Flexural displacement			
(a) With far end fixed		$\frac{L}{4EI}$	$\frac{4EI}{L}$
(b) With far end hinged		$\frac{L}{3EI}$	$\frac{3EI}{L}$

Truss	Frames
In truss forces act only along the axis of the members. Members are having tension or compression.	In frames forces are acting along the axis of the member, in addition to transverse forces.
Each member is acted upon by two equal and opposite forces having line of action along the centre of members. (every member of truss is a two force member.)	One or more than one member of frame is subjected to more than two forces (multiple force members).
Forces are applied at the joints only.	Forces may act anywhere on the member.
Member does not bend.	Members may be bend
Used for large loads.	Used for small & medium loads.

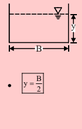
S.SOROUT, 9255624029

FOLLOWING BOOKS AVAILABLE BY **CIVIL Ki GOLI PUBLICATION :**

1. **CIVIL Ki GOLI**
2. **CIVIL BOOSTER**
3. **REASONING Ki GOLI**
4. **HARYANA Ki GOLI**

- **Sudden expension:** $h_l = \frac{(v_1 - v_2)^2}{2g}$
- **Entry Loss:** $h_{entry} = 0.5\frac{v^2}{2g}$, **Exist of Pipe:** $h_{exit} = \frac{v^2}{2g}$
- **Sudden Contraction:** $h_{contraction} = \frac{(v_c - v_2)^2}{2g}$
- **Bending of the Pipe:** $h_{fitting} = k\frac{v^2}{2g}$, k = constant, T-Bend, k = 1.8, 90°-Bend, k = 1.2, 45°-Bend, k = 0.4

Chart for Most Economical Sections

Geometrical Parameters	Rectangular	Triangular	Trapezoidal
Diagram			
Condition for most Economical	$y = \frac{B}{2}$	m = 1, θ = 45°	$B = \frac{2y}{\sqrt{3}}$, $m = \frac{1}{\sqrt{3}}$, θ = 60° Hor. θ = 30° Vert.
Area	$A = B.y = 2y.y$	$A = my^2$	$A = (B + my) \times y$
	$A = 2y^2$	$A = y^2$	$A = \left(\frac{2y}{\sqrt{3}} + \frac{1}{\sqrt{3}}y\right)y = \left(\sqrt{3}\right)y^2$
Perimeter	$P = 4y$	$p = 2\sqrt{2}y$	$P = 2\sqrt{3}y$
Hydraulic Radius (R = A/P)	$R = y/2$	$R = \frac{y}{2\sqrt{2}}$	$R = \frac{y}{2}$
Top width (T)	$T = 2y$	$T = 2y$	$T = \frac{4y}{\sqrt{3}}$
Hydraulic Depth $\left(D = \frac{A}{T}\right)$	$D = y$	$D = y/2$	$D = \frac{3}{4}y$

Note: Circular section (a) For maximum discharge 2θ = 302°22′, d = 0.938 D, (b) For maximum velocity 2θ = 257°27′, d = 0.81 D

Type of flow	Depth of flow	Velocity of flow	Froude No	Comments
Subcritical	$y > y_c$	$v < v_c$	$F_r < 1$	As streaming or transquil flow
Critical	$y = y_c$	$v = v_c$	$F_r = 1$	
Super Critical	$y < y_c$	$v > v_c$	$F_r > 1$	Shooting flow, rapid flow, torrential flow

Dynamic eq. for G.V.F.: $\frac{dy}{dx} = \left(\frac{S_o - S_f}{1 - \frac{q^2}{gy^3}}\right)$

Hydraulic Jump Eq.

1. $\frac{2q^2}{g} = y_2y_2(y_1 + y_2)$, 2. Energy Loss $E_L = \frac{(y_2 - y_1)^3}{4y_1y_2}$

3. $\frac{y_2}{y_1} = \frac{1}{2}\left(\sqrt{1 + 8F_r^2} - 1\right)$, 4. $y_1' = \frac{y_1y_2(y_1 + y_2)}{2}$

Types of Jump	Fr	E_2/E_1	Water surface
Undular	1–1.7	≈ 0	Undulating
Weak	1.7–2.5	5–18%	Small rollers form
Oscillating	2.5–4.5	18–45%	Water oscillates in random manner
Steady strong	4.5–9 ≥ 9	45–70% ≥ 70%	Roller and jump action Very rough and choppy

$N_s = \frac{N\sqrt{P}}{(H)^{5/4}}$ (for Turbine), $N_s = \frac{N\sqrt{Q}}{(H_m)^{3/4}}$ (for Pump)

	Laminar	Transition	Turbulent
Flow in pipe	$R_e < 2000$	$2000 < R_e < 4000$	$R_e > 4000$
Flow between parallel plate	$R_e < 1000$	$1000 < R_e < 2000$	$R_e > 2000$
Flow in open channel	$R_e < 500$	$500 < R_e < 2000$	$R_e > 2000$
Flow through soil	$R_e < 1$	$1 < R_e < 2$	$R_e > 2$

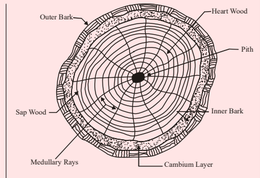
BMC

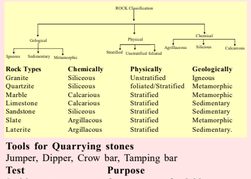
Test of Cement

- FINENESS TEST
  - Sieve Method
  - Air permeability Method
  - (Nurse and Blaine's method)
  - Sedimentation method
  - (Wanger Turbidimeter Method)
- CONSISTENCY TEST
  - Vicat's Apparatus.
- SETTING TIME
  - Vicat's Apparatus.
- SOUNDNESS TEST
  - Le-chatelier Method
  - Auto clave test
- TENSILE STRENGTH
  - Briquette test
- HEAT OF HYDRATION
  - Calorimeter test
- SPECIFIC GRAVITY TEST
  - Le-chatelier's Flask.

Test On Concrete

- WORKABILITY
  - Slump test
  - Compacting factor Test
  - Vee-bee consistometer method
- DIRECT TENSILE STRENGTH OF CONCRETE
  - Cylinder Splitting Test
- BOND B/W CONCRETE &STEEL
  - Pull out Test
- COMPRESSIVE STRENGTH
  - Rebound hammer Test
- DYNAMIC MODULUS





Rock Types	Chemically	Physically	Geologically
Granite	Siliceous	Unstratified	Igneous
Quartzite	Siliceous	foliated/Stratified	Metamorphic
Marble	Calcarious	Stratified	Metamorphic
Limestone	Calcarious	Stratified	Sedimentary
Sandstone	Siliceous	Stratified	Sedimentary
Slate	Argillaceous	Stratified	Metamorphic
Laterite	Argillaceous	Stratified	Sedimentary.

Tools for Quarrying stones
Jumper, Dipper, Crow bar, Tamping bar

Test	Purpose
Smith test	for presence of soluble matter
Brard's test	for frost resistance
Acid test	To check weather resistance
Hardness test	Mohr scale

Window Width = $\frac{1}{8}$[Width of room + Height of Room]

- The sill of a window should be located about (70 – 80) cm above floor level of the room.
- Generally Height of a Door should not be less than (1.8 – 2) m
- Commonly Width height relation used in India:
  (i) Width = (0.4 – 0.6) Height
  (ii) Height = (Width + 1.2) m
- Doors of residential Buildings:
  (a) External Door – (1 × 2) to (1.1 × 2) m
  (b) Internal Door – (0.9 × 2) to (1 × 2) m
  (c) Doors for bathrooms and Water closets:
  – (0.7 × 2) to (0.8 × 2) m
- Public Buildings (School, Hospital, library)
  (a) (1.2 × 2) m (b) (1.2 × 2.1) m (c) 1.2 × 2.25) m
  Designation of Door = Length × Type of Door × Height
  8 DS 20 – A door opening Having width (8 × 100 mm) × Height (20 × 100 mm) with S (Single SHutter) D (Door)

Types of Window

1. fixed 2. Pivoted 3. Sliding 4. Bay 5. Corner 6. Cable (7) Dormer (8) Skylights (9) Louvered (10) Lantern (11) Gable

Stairs

- No of steps are not more than 12 and not less than 3 in a flight.
- Angle of Inclination (Pitch) – (25° – 40).
- Head room must not be less than 2.05 m.
- Minimum width of stairs in residential building – 85 cm and in commercial building is 1 m.

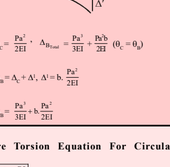
Type of Structure	Degree of Indeterminacy D_s
2D (plane) frames	(3m+r)-3j
3D frames	(6m + r)-6j
2D (plane) pin-jointed truss	(m+r)-2j
3D truss	(m+r)-3j

Slope Deflection Equations

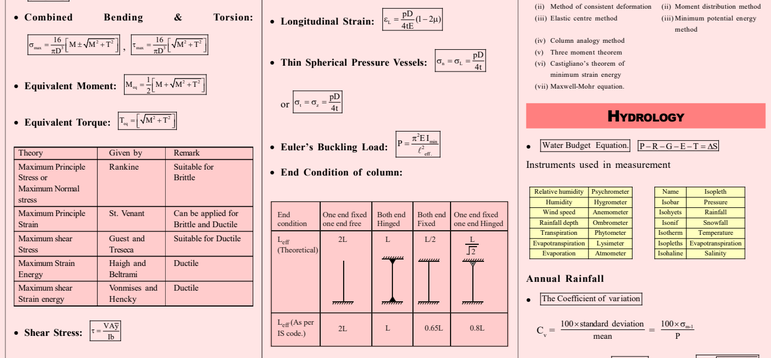
$M_{AB} = M_{FAB} + \frac{2EI}{l}\left(2\theta_A + \theta_B - \frac{3\delta}{l}\right)$ (Continuous Beam)

$M_{BA} = \frac{3EI}{L}\theta_B - \frac{3EI}{L^2}\delta = \frac{d\,\phi}{1.4}$ (one end is pin supported)

Important Points



Slope & Deflection



- **Pure Torsion Equation For Circular Shaft:** $\frac{T}{J} = \frac{\tau}{r} = \frac{G\theta}{L}$
- **Combined Bending & Torsion:** $\sigma_{max} = \frac{16}{\pi D^3}\left[M \pm \sqrt{M^2 + T^2}\right]$, $\tau_{max} = \frac{16}{\pi D^3}\left[\sqrt{M^2 + T^2}\right]$
- **Equivalent Moment:** $M_{eq} = \frac{1}{2}\left[M + \sqrt{M^2 + T^2}\right]$
- **Equivalent Torque:** $T_{eq} = \left[\sqrt{M^2 + T^2}\right]$

Theory	Given by	Remark
Maximum Principle Stress or Maximum Normal stress	Rankine	Suitable for Brittle
Maximum Principle Strain	St. Venant	Can be applied for Brittle and Ductile
Maximum shear Stress	Guest and Treseca	Suitable for Ductile
Maximum Strain Energy	Haigh and Beltrami	Ductile
Maximum shear Strain energy	Vonmises and Hencky	Ductile

- **Shear Stress:** $\tau = \frac{VAy}{Ib}$
- **Shear Stress In Rectangular Section:** $q = \frac{6q}{bd^3}\left(\frac{d^2}{4} - y^2\right)$ (q = τ).
- **Hoop Strain:** $\varepsilon_h = \frac{pD}{4tE}(2 - \mu)$
- **Longitudinal Strain:** $\varepsilon_L = \frac{pD}{4tE}(1 - 2\mu)$
- **Thin Spherical Pressure Vessels:** $\sigma_x = \sigma_1 = \frac{pD}{4t}$ or $\sigma_1 = \sigma_2 = \frac{pD}{4t}$
- **Euler's Buckling Load:** $P = \frac{\pi^2 EI_{min}}{l'^2_{eff}}$
- **End Condition of column:**

End condition	One end fixed one end free	Both end Hinged	Both end Fixed	One end fixed one end Hinged
L_{eff} (Theoretical)	2L	L	L/2	$\frac{L}{\sqrt{2}}$
L_{eff} (As per IS code.)	2L	L	0.65L	0.8L

4. $D_s < D_d$
Force Method/Flexibility Method/ Compatibility Method
5. (i) Virtual work/Unit load method
(ii) Method of consistent deformation
(iii) Elastic centre method
(iv) Column analogy method
(v) Three moment theorem
(vi) Castigliano's theorem of minimum strain energy
(vii) Maxwell-Mohr equation.

4. $D_s < D_d$
Displacement Method/Stiffness Method/Equilibrium Method
(i) Slope deflection method
(ii) Moment distribution method
(iii) Minimum potential energy method

4. No eq. for bed slope
5. Recommended Kutter eq. to find velocity
6. Trial & error procedure

4. Gave eq. to calculate bed slope
5. Gave his own velocity equation
6. Direct procedure

- **Shaft In series:**

Note: On principle plane shear stress will always 0.

- **Radius of Mohr's Circle (τ_{max}):** $R = \frac{\sigma_{max} - \sigma_{min}}{2} = \tau_{max}$
- **Normal stress at Location of (τ_{max}) (τ_{max}-max shear stress):** $\sigma_n = \frac{\sigma_1 + \sigma_2}{2}$
- **Volumetric Strain of Rectangular:** $\frac{\Delta V}{V} = \varepsilon_v = \left[\frac{(\sigma_x + \sigma_y + \sigma_z)}{E}\right](1 - 2\mu)$
- **Volumetric Strain of Cylindrical:** $\varepsilon_v = \varepsilon_L + 2\varepsilon_0$
- **Volumetric Strain of Spherical:** $\varepsilon_v = 3\varepsilon_0$
- **Relationship Between Elastic Constant:**
  $G = \frac{E}{2(1+\mu)}$, $K = \frac{E}{3(1-2\mu)}$, $\mu = \frac{3k - 2G}{6k + 2G}$, $E = \frac{9kG}{3k + G}$
  Number of independent Elastic Constant: Homogenous & Isotropic = 2, Anisotropic = 21, Orthotropic = 9
- **Axial Elongation of the Prismatic Bar:**
  $\Delta L = \frac{PL}{AE}$, $\Delta L = \frac{2PL}{AE}$ (for Instantaneous loading)
- **Deflection In Non-Prismtic Bars:**
  1. **Stepped Bar:** $\Delta l = \frac{PL_1}{A_1E_1} + \frac{PL_2}{A_2E_2} + \cdots$
  2. **Circular Tapering Bar:** $\Delta L = \frac{4PL}{\pi E D_1 D_2}$
  - **Defection of Composit Bar:** $\Delta L_1 = \Delta L_2 \Delta = \frac{PL}{A_1E_1 + A_2E_2}$
  - **Deflection due to Self Weight of Bar:**
  1. **Prismatic Bar:** $\Delta = \frac{WL}{2AE} = \frac{\gamma L^2}{2E}$,
  2. **Conical Bar:** $\Delta = \frac{WL}{2AE} = \frac{\gamma L^2}{6E}$
- **Thermal Expansion:** σ = EαΔT, Δ = LαΔT
  Coefficient of Thermal expansion (Aluminium > Brass > Copper > Steel)
  $P_{cr} = \frac{\pi^2 EA}{\lambda^2}$ (Euler's Theory) $P_R = \frac{\sigma_c A}{1 + \alpha\lambda^2}$ (Rankine's Formula)
- **In case of Pure Bending:** $Z = \frac{\pi}{32}D^3$
- **In case of pure Torsion:** $\tau_{max} = \frac{T}{Z_p} = \frac{16T}{\pi D^3}$, $Z_p = \frac{\pi}{16}D^3$
- **Bending Equation:** $\frac{\sigma_b}{y} = \frac{M}{I} = \frac{E}{R}$

HYDROLOGY

- Water Budget Equation. $P - R - G - E - T = \Delta S$

Instruments used in measurement

Relative humidity	Psychrometer
Humidity	Hygrometer
Wind speed	Anemometer
Rainfall depth	Ombrometer
Transpiration	Phytometer
Evapotranspiration	Lysimeter
Evaporation	Atmometer

Name	Isopleth
Isobar	Pressure
Isohyets	Rainfall
Isonif	Snowfall
Isotherm	Temperature
Isopleths	Evapotranspiration
Isohaline	Salinity

Annual Rainfall

- The Coefficient of variation $C_v = \frac{100 \times \text{standard deviation}}{\text{mean}} = \frac{100 \times \sigma_{n-1}}{P}$
- Number of Stations $N = \left(\frac{C_v}{E}\right)^2$, $\varepsilon < 10\%$, $\sigma_{n-1} = \sqrt{\frac{\sum^n (P - \bar{P})^2}{m - 1}}$,

$f_c = f_c + (f_o - f_c)e^{-kt}$,
f_c = Infiltration capacity at any time t,
f_o = initial infiltration,
f_c = Final steady state infiltration.

IRRIGATION

Methods of Irrigation
Free flooding, Border flooding, Check flooding, Basin flooding, Furrow Irrigation, sprinkler Irrigation, Drip Irrigation.

- **Sodium Absorption Ratio:** $SAR = \frac{Na^+}{\sqrt{\frac{Ca^{++} + Mg^{++}}{2}}}$
- **Depth of water stored in root zone:** $d_{rz} = \frac{d_1\gamma_d}{\gamma_w}(F_C - M_d)$
- **Relation b/w duty and Delta:** $\Delta = \frac{8.64B}{D}$(meter),
  B = Base period in days, D = Duty in hectare/cumec
- **Irrigation Efficiency**
  (a) **Water conveyance Efficiency:** $\eta_c = \frac{W_f}{W_r} \times 100$,
  W_f = water delivered to the farm, W_r = water supplied
  (b) **Water appliacation Efficiency (η_a):** $\eta_a = \frac{W_s}{W_f} \times 100$
  Below the farm root-zone $W_d = W_s + R_p + D_p$,
  W_s = Water stored in the root zone,
  W_f = Water delivered to the farm,
  R_p = Surface run off, D_p = deep percolation
  (c) **Water use efficiency (η_u):** $\eta_u = \frac{w_n}{w_d} \times 100$,
  w_n = water used beneficialy,
  w_d = water delivered.
  (d) **Water Storage Efficiency (η_s):** $\eta_s = \frac{W_s}{W_n} \times 100$,
  W_n = water needed in the root zone prior to Irrigation,
  W_s = (field capacity–Available moisture)
  (e) **Water Distribution Efficiency (η_d):**
  $\eta_d = 100\left(1 - \frac{Y}{d}\right)$, Y = average numerical deviation in depth of water average depth stored during Irrigation (d).
- **Consumption Irrigation Requirements (CIR):** $CIR = C_u - R_e$
  Field Irrigation Requirement (FIR): $FIR = \frac{NIR}{\eta_a}$
  Gross Irrigation Requirement: $GIR = \frac{FIR}{\eta_c}$
  $NIR = CIR + LR + PSR + NWR$, (GIR > FIR > NIR > CIR)
- **Kennedy's theory:** $V_o = 0.55 m y^{0.64}$
- **Kutter's/ chezy's Formula:** $V = \frac{23 + \frac{0.00155}{S} + \frac{1}{n}}{1 + \left(23 + \frac{0.00155}{S}\right)\frac{n}{\sqrt{R}}}\sqrt{RS}$
- **Lacey's Theory:** $V = \left(\frac{Qf^2}{140}\right)^{1/6}$, $f = 1.76\sqrt{d_{mm}}$
- $R = \frac{5}{2}\left(\frac{V^2}{f}\right)$, $S = \frac{f^{5/3}}{3340\,Q^{1/6}}$, $A = \frac{Q}{v}$
  wetted perimeter $P = 4.75\sqrt{Q}$ scour depth = $1.35\left(\frac{q^2}{f}\right)^{1/3}$

Difference B/W Lacey & Kennedy Theory

Kennedy	Lacey
1. Trapezoidal channel	1. Semi elliptical channel
2. Applicable for alluvial channels	2. Applicable for alluvial channels as well as for rivers.
3. Silt is kept in suspension due to eddies generated from bottom.	3. Silt is kept in suspension due to eddies generated both from side slope and the bottom i.e. through out the parameter.

- **By Rate of introduction of super elevation:** $L_s = e.N.(w + w_e)$ (Rotation about inner edge), $L_s = \frac{e.N.(w + w_e)}{2}$ (Rotation wrt centre line)
- **Empirial Formula:** $L_s = \frac{2.7v^2}{R} - C$(Plain & Rolling), $L_s = \frac{v^2}{R} - C$(Hilly area)
- **Length of Summit Curve:** $L = 2S - \frac{4.4}{N}$ **(L<SSD)**
  $L = \frac{NS^2}{4.4}$ **(L>SSD)**
- **Length of Valley Curve:** $L_s = 2\left(\frac{Nv^{1.3}}{C}\right)$ (Comfort criteria)
- **L > SSD:** $L = \frac{NS^2}{(2h_1 + 2S\sin\alpha)} = \frac{NS^2}{(1.5 + 0.035S)}$ ($h_1 = 0.75$, $\alpha = 1°$)
- **L< SSD:** $L = 2S - \frac{(2h_1 + 2S\sin\alpha)}{N}$
- **Basic Capacity of Single lane, Vehicle Per hours:** v = speed kmph, T(Sec/km) = $\frac{3600}{v}$, $q_{max} = \frac{v.k_j}{4}$,
  Where,
  v_f= Free mean speed, (Maximum speed at zero density.),
  k_j = jam density, (Maximum density at zero speed), Maximum flow q_{max} occurs when the speed is $\frac{v_f}{2}$ and density is $k_j/2$.
  Number of potential conflicts: Both roads are two way = 24, Both road one way = 6, One road is two way, other one way = 11
- $Q = \frac{280w\left(1 + \frac{v}{5}\right)\left(1 - \frac{p}{2}\right)}{\left(1 + \frac{w}{l}\right)}$, $W_{weaving} = \frac{e_1 + e_2}{2} + 3.5$ (Types of interchange: Trumpet, Diamond, Full Cloverleaf, Partial Cloverleaf

Floating Car Method: For Speed and delay study.

- **Aggregate crushing value:** $\frac{w_2}{w_1} \times 100$
- **Coefficient of Hardness:** $= 20 - \frac{\text{Loss of wt. in gm}}{3}$
- **Rigidity factor:** $R.F = \frac{\text{Contact Pressure}}{\text{Tyre Pressure}}$
- **California Resistance Value:** $t = \frac{k.(T.1)(90 - R)}{C^{2.5}}$
- **Elastic Modulus:** Δ is maximum vertical deflection of the flexible plate, $\Delta = \frac{1.18pa}{F_s}$, Rigid circular plate is used instead of flexible $\Delta = \frac{1.5Pa}{F_s}$, a = radius of plate, p = pressure at deflection, E_s = young's modulus of pavement material.
- **California Bearing Ratio M/D:** $t = \left(\frac{1.75P}{CBR} - \frac{A}{\pi}\right)^{1/2}$, t = Pavement thickness in Cm, P = wheel load in kg, CBR = California Bearing Ratio (%), A = Contact Area in cm^2
- **CBR TEST:** $CBR = \frac{\text{Load or pressure Substained at 2.5 or 5.0 mm Penetration}}{\text{Load or pressure Substained by standard aggregate at corresponding pressure level.}}$
- **Tri Axial Method:** $T_v = \left(\sqrt{\frac{2p_1 \times y}{2\pi E_s h}} - d\right)\left(\frac{E_s}{E_p}\right)$, $\frac{L_1}{L_2} = \left(\frac{E_s}{E_1}\right)^{1/3}$
- **Design of Rigid Pavement:** $k = \frac{p}{\Delta} = \frac{P}{0.125}$
- **Radius of Relative Stifness:** $l = \left[\frac{Eh^3}{12K(1 - \mu^2)}\right]^{1/4}$,
  $b = \sqrt{1.6a^2 + h^2} - 0.675h$ when (a < 1.724 h)
  $S_l = \frac{3P}{h^2}$ (Glodbeck's formula)
  $N = \frac{365A[(1+r)^n - 1]}{r} \times FD$

Bankelman Beam Deflection Method

Overlay Thickness: $h_0 = 550\log_{10}\frac{D_o}{D_a}$

Test	Purpose
CBR test	For classifying & evaluating soil subgrade & base course materials for flexible pavements
Crushing test	Strength of Aggregate
Abrasion test	Hardness of Aggregate
Impact test	Toughness of Aggregate
Soundness test	Durability of Aggregate
Shape test	Gives idea of workability & stability of mix
Bitumen Adhesion test	Gives stripping value of Aggregates
Softening point test	It is done by Ring & ball apparatus to ensure safety of Bitumen
Float test	for viscosity of Bitumen.

S.SOROUT, 9255624029
FOLLOWING BOOKS AVAILABLE BY
CIVIL Ki GOLI PUBLICATION:
1. CIVIL Ki GOLI
2. CIVIL BOOSTER
3. REASONING Ki GOLI
4. HARYANA Ki GOLI
5. SOLUTION OF CIVIL Ki GOLI
6. ELECTRICAL & MECHANICAL ENGINEERING ROCKET CHART
7. CIVIL'S CAPSULE

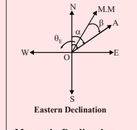
HIGHWAY ENGINEERING

Roman Roads → Tresaguet Construction → Metcalf Construction → Telford Construction → Macadam Construction
Nov. 1927 → Jayakar Committee formed
Feb. 1928 → Recommendations by Jayakar Committee

RAILWAY ENGINEERING

Surveying Chain: Revenue chain (33 ft), Gunter's chain (66 ft), Engineer's chain (100 ft), Metric chain
Equipments for Measurement Right Angles: Cross staff, optical square, Prism square.

- **Tap Corrections:**
- **Correction for Slope:** $C_s = L - \sqrt{L^2 - h^2}$
- **Correction for alignment or bad ranging:** $C_a = \frac{h^2}{2L}$
- **Correction for Temperature:** $C_t = \alpha\,(T_m - T_o)L$
- **Correction for pull or Tension:** $C_p = \frac{(P - P_o)L}{AE}$
- **Correction for Sag:** $C_s = -\frac{L(wL)^2}{24P^2}$
- **Important Terms**
- **Bearing:** Direction of a line with respect to fixed meridian is called bearing.
- **True Meridian/Bearing**
  → True meridian is a line joining True North pole, True South Pole end and point of reference. **It never changes with time.**
  → Angle measured for any line w.r.t True Meridian is called Ture bearing.
- Bearing Taken W.r.t magnetic meridian is called magnetic Bearing.



Magnetic Declination

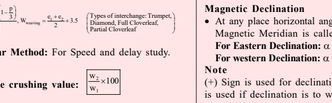
- At any place horizontal angle b/w True Meridian and Magnetic Meridian is called magnetic Declination.
  For Eastern Declination: α = B + θ_o or T.B = M.B +θ_o
  For western Declination: α = B – θ_o or T.B = M.B – θ_o

Note
(+) Sign is used for declination is to the east, sign (–) is used if declination is to west

Fore bearing and Back Bearing: B.B = F.B ± 180°
Local Attraction: F.B – B.B ≠ 180°
Latitude and Departure
→Projection of a line on N-S direction is called latitude: $L = l\cos\theta$
→Projectione of a line on E-W direction is called deparature: $D = l\sin\theta$

Adjustment of closing Error.

- Sum of all internal Angles of a closed Traverse: (2n–4)×90° where n = No. of sides.
- Sum of all deflection Angle = 360°
- Sum of latitude: $\Sigma L = 0$
- Sum of departure: $\Sigma D = 0$
- **Closing error In the Traverse:** $e = \sqrt{(\Sigma L)^2 + (\Sigma D)^2}$
- **Bowditch's Method (Compass Rule)**
  Permissible error in linear Measurment $e\alpha\sqrt{l}$
  Permissible error in angular measurement $e\alpha\frac{1}{\sqrt{l}}$
- **Correction to latitude:** $C_L = \Sigma L \times \frac{l}{\Sigma l}$
- **Correction due to departure:** $C_D = \Sigma D \times \frac{l}{\Sigma l}$
- **Transit Method:** $C_L = \Sigma L \times \frac{L}{L_r}$, $C_D = \Sigma D \times \frac{D}{D_r}$
- **Axis Method.**
  Correction of any length: That length × $\frac{\frac{1}{2}\text{closing error}}{\text{Length of Axis}}$



- **Sensitivity:** Angle b/w the line of sights in radius $\alpha = \frac{S}{D} = n \times \frac{l}{R} = \left(\frac{l}{R} = \frac{S}{nD}\right) \times 206265$
  D = Distance of the instrument from the staff
  n = Number of divisions
  l = length of one division (2mm)
  R = Radius of curvature
  S = Staff intercept.
- **Check in Height of Instrument Method**
  Σ BS– Σ FS = Σ Rise – Σ Fall = Last RL–First RL
- **Curvature:** $C_c = -\frac{d^2}{2R} = -0.0785d^2$. **•Refraction:** $C_r = \frac{1}{7}\left(\frac{d^2}{2R}\right)$
- **Final Combination Correction:**
  $C = C_c - C_r = -\frac{6}{7}\left(\frac{d^2}{2R}\right) = -0.06735d^2$
- **Distance of Visible Horizon**
  $d = 3.85\sqrt{h}$, d = in km and h = in meter.
- **Reciprocal Levelling:** The true difference Elevation: $H = \frac{1}{2}[(h_1 - h_2) + (h_1' - h_2')]$
- **Determining Areas:** Mid ordinate rule Δ (Area) = Average ordinate × Length of base, $\Delta = \frac{O_1 + O_2 + \ldots + O_n}{n} \times L$
- **Average ordinate Rule:** Area D = Average ordinate of the base= $\left(\frac{O_1 + O_1 + \ldots + O_n}{n+1}\right) \times L$, $D = \frac{L}{(n+1)} \times \Sigma D$,

ENVIRONMENTAL ENGINEERING

- **Variation of Demand**
  Max. daily Consump. = 1.8 × Annual avg. daily consump.
  Maximum Weekly Consumption = 1.48 ×Avg. weekly
  Maximum Monthly Consumption = 1.28 × Avg. monthly.
- **Population Forecasting Mehtod**
  Arithmetic Increase Method: $P_n = P_o + n\bar{x}$ (For old cities)
  Geometric Increases Method: $P_n = P_o\left(1 + \frac{x}{100}\right)^n$ (For new cities)
  Incremental Increase Method: $P_n = P_o + n\bar{x} + \frac{n(n+1)}{2}\bar{y}$

- **Physical characteristics**
  Turbidity: (limit 1-5 NTU) Baylis, Jackson, Nephelometer
  Colour: Tintometer (limit 5-15 TCU), **Taste & odour:** T.O.N = 1 (↓3)
  Temperature: 10°C desirable (↑25°C)
  Total solid = Dissolved solids + Suspended solids (Gravimetric Method)
- **Chemical Characteristics**
  Total solids & suspended solids: Limit 500-2000 ppm
  PH = – log H^+ (6.6 to 8.5) Methyl Orange & Phenolphthalein
  Total Hardness: $[Ca^{++}] \times \frac{50}{20} + [Mg^{++}] \times \left(\frac{50}{12}\right)$ (EDTA using EBT)
  Carbonate Hardness: min of total hardness or alkalinity
  Chloride: limit – 120mg/L (Water), 250 mg/L (Sewage)
  Nitrogen Content: Limits: Free ammonia ↓0.15mg/L, Organic Nitrogen ↓ 0.3 mg/l, nitrite should be zero, nitrate ↓ 45 mg/l
  Measurement (i) Free Ammonia-by simple boiling of water. (ii) Organic Ammonia – By adding $Kmno_4$, (i+ii) are known as **kjeldahl Nitrogen** Nitrite and Nitrate by - colour Matching Method.
  Chemical: (Mn = 0.05 mg/L) (Iron – 0.3 mg/L), (Fluride : 1.0 –1.5 mg/L) (Sulphate : 250 mg/L) (Cyanides = 0.2mg/L) (Arsenic : 0.01 ppm)
  Screening: Velocity ↑0.8 to 1m/sec
  Based on stokes law. Setting velocity: $V_s = \frac{Q}{BL}$
- **Design Criteria:** Over flow rate = $\frac{Q}{BH}$, 500–750 lit/hr/m2 for plain sedimentation, Depth = 03 to 4.5m Width B ≈ 10 m
- **Coagulants**
  1. Use of Alum
  2. Use of copperas: $(FeSo_4.7H_2O)$
  3. Use of chlorinated copperas $(Fe.(So_4)_3 + FeCl_3)$.
  4. Use sodium Aluminate $(Na_2Al_2O_4)$

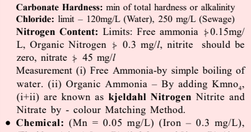
Comparision of slow sand and Rapid Gravity Filters.

Slow sand filter	Rapid sand filter
$C_u = 3–5$	$C_u = 1.2–1.6$
$D_{10} = (0.2–0.3)$ mm	$D_{10} = (0.35–0.55)$ mm
Frequency of cleaning = (1–3) months	Cleaned through Back washing
Design period = 10 year	$n = 1.22\sqrt{Q}$
Use for smaller plants in village	Rate of filtration (3000-6000)
Design on max. daily demand.	$l/m^2/hr$
Rate of filtration (100-200) $l/m^2/hr$ is very low as compared to R.S.F., but efficiency is High	Operational Troubles– (a) Air Binding (b) Mud ball formations (c) Cracking of filter

1. Minor Methods.
(i) Boiling, (ii) Treatment with excess lime, (iii) Treatment with ozone $(KMNO_4)$, (iv) Treatment with silver Process.
2. Major Method Chlorination (Disinfection with Cl_2)

- $Cl_2 + H_2O \xrightarrow{pH<3} HOCl + HCl$, • $HOCl \xrightarrow{pH>3} H^+ + OCl^-$
- $HOCl + \xrightarrow{pH<3} H^+ + OCl^-$, • $NH_2 + HOCl \rightarrow NH_2Cl + H_2O$

NH_2 + HOCl is called combined chlorine.
Chlorine forms: Free chlorine, Hypochlorites (Swimming Pool), Chloramines, Chlorine dioxide



Treatment With Water
1. Treatment with Copper Sulphate $(CuSO_4.H_2O)$

- Added to open reservoir and lakes to kill algae or to check the growth.

2. Treatment with $KMNO_4$

- Acts as oxidizing agent to remove to taste, odour and colour and to kill bacteria.

3. Aerations

- For increasing Di-oxygen to remove CO_2, upto some extent removal of Fe and Mn.

4. Fluoridation

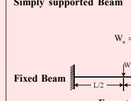
- Necessary if F < 1mg/L. Add Naf or Na_2SiF_6 or H_2SiF_6 to keep fluorine content between 1 to 1.5 mg/L

(1) De-Fluoridation. (if F > 1.5 mg/L) In India, Treatment is done by Nalgonda Technique (Use Alum for reducing flurides)
5. Removal of Radioactive Substances By coagulation & filtration.
6. Desalination (i) By evaporation and distillation (ii) Electrodialysis (iii) Reverse Osmosis.

- **Hydraulic design of sewers:** $V = \frac{1}{n}R^{2/3}S^{1/2}$
- **Oxygen Demand:** $\frac{dL}{dt} = -KL, L_t = L_0 - 10^{-k_1}D^1$,
  $BOD_t = L_o - L_t = L_o\left[1 - 10^{-k_1 t}\right]$, $[BOD_5 = 0.684L_0]$,
  $K_{(T^o)} = KD_{20}\,[1.047]^{T-20}$

Member	λmax
A member carrying compressive load resulting from dead load and imposed load	180
A tension member in which reversal of direct stress due to load other than wind and seismic force	180
A member subjected to compressive forces resulting from wind EQ force provide deformation of such member does not affect stress	250
Compression flange of Beam against lateral torsional buckling.	300
A member normally act as a tie in Roof Truss	350
Tension member other than Pre-tension	400

- Strength of plate between rivet holes in Tension = $\sigma_{at} \times (p\text{-}d) \times t$
- Bearing strength of rivet = $\sigma_{at} \times d \times t$ or = $\sigma_{pr} \times d \times t$.
- Shear Strength of rivet = $T_{sr} \times \frac{\pi}{4} \times d^2$ (in single shear), $2 \times T_{sr} \times \frac{\pi}{4} \times d^2$ in double shear), d = gross diameter of rivet, $d = 6.01\sqrt{t}$ (unwins formula)
- **Diameter:** Grosss diameter = nominal diameter + 1.5 mm (if ≤ 25mm), Nominal diameter + 2mm (if > 25mm)
- **Pitch:** Should not exceed 16t or 200mm, which ever is less in tension member, and 12t or 200mm, which ever is less in Compression Members. Tacking rivets should not exceed 32 t or 300 mm which ever is less. Minimum pitch = 2.5d
- **Force due to axial load on each rivet:** $F_a = \frac{W}{n}$
- **Force due to moment M on any rivet:** $F_m = \frac{M \times r}{\Sigma h^2}$
- **Area along Section:** $A_{ns} = t\left[b - n \times d + \left(\frac{S^2}{4 \times g_1} + \frac{S^2}{4 \times g_2}\right)\right]$
- **Net Effective Area:**



$A_{ns} = A_s + A_1 \times k_1$, $k_1 = \frac{3 \times A_1}{3 \times A_1 + A_2}$,
$A_1 = (l_1 - t/2 - d)t$, $A_2 = (l_2 - t/2) \times t$,
$A_{ns} = (l_1 + l_2 - t)t$

- For pair of Angle Placed back to back connected by only one lag of each angle.

$A_{ns} = A_1 + A_2 \times k_2$, • $K_2 = \frac{5 \times A_1}{5 \times A_1 + A_2}$

The area of a web of Tee = Thickness of web × (depth - thickness of flange)

- **Sec Modulus**

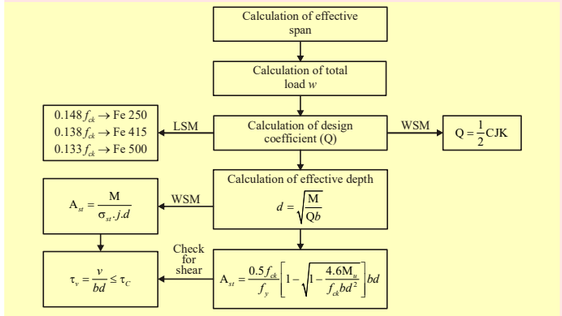
$E_c = 5700\sqrt{f_{ck}}\ N/mm^2.$, **Min. grade = M15 (IS 456:1978)**

$E_c = 5000\sqrt{f_{ck}}\ N/mm^2.$, **Min. grade = M20 (IS 456:2000)**

S. No.	Discription	Collapse	Servicability
1.	D.L + L.L	1.5	1
2.	D.L + (W.L) or (E.L) combination		
	(i) for normal case D.L + W.L (or E.L) D.L + W.L (or E.L)	1.5	1
	(ii) for checking stability against over turning/stress reversal D.L + W.L (or E.L)	0.9	1
3.	D.L + (L.L) + W.L (or E.L) combination	1.2	1
	D.L	1.2	0.8
	W.L (or E.L)	1.2	0.8

$m = \frac{280}{3\sigma_{cbc}}$ $\quad f_{cr} = 0.7\sqrt{f_{ck}}, f_{ct} = 0.66 f_{cr} = \frac{2p}{\pi DL}$

f_{cr} (flexure > Splitting > Direct Tensile strength)



For Singly Reinforced Rectangular beam

Unbalanced Section	Balanced Section
$k = \frac{1}{1+\frac{\sigma_{st}}{mf_c}} = \frac{mf_c}{\sigma_{st}+mf_c}$	$k_c = \frac{m\sigma_{cbc}}{\sigma_{st}+m\sigma_{cbc}}$ (if m is given)
$R = \frac{1}{2} f_c k\left(1-\frac{k}{3}\right)$	$R_c = \frac{1}{2}\sigma_{cbc} k_c\left(1-\frac{k_c}{3}\right)$
$M = Rbd^2 = A_{st} f_{st}\left(d-\frac{n}{3}\right) = A_{st} f_{st}\, d\left(1-\frac{k}{3}\right)$	$M_c = R_c bd^2 = A_{st}\sigma_{st}\left(d-\frac{n_c}{3}\right) = A_{st}\sigma_{st}\, d\left(1-\frac{k_c}{3}\right)$
$P = \frac{A_{st}}{bd}\times 100 = \frac{50kf_c}{f_{st}}$	$P_c = \frac{A_{st}}{bd}\times 100 = \frac{50k_c\sigma_{cbc}}{\sigma_{st}}$

- **Doubly Reinforce Rectangular Setction**

$\frac{bx^2}{2} + (m^1-1)A_{st}(x-d') = m\,As(d-x)'$

- **FLexure (LSM)- Balanced Section**

$\left(\frac{x}{d}\right)_{max} = \frac{700}{0.87f_y + 1100}$

- **Design of S.R Rectangular Section**

$d = \sqrt{\frac{\gamma_f M}{R_u b}}$ $\quad A_s = \frac{y_f M}{0.87 f_y\, jd}$

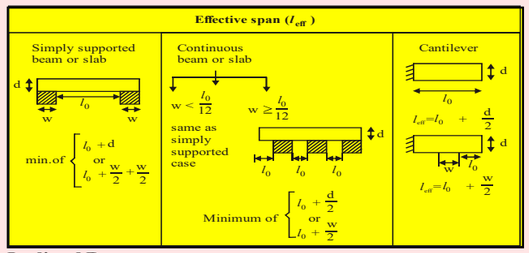
- **Analysis of Doubly Reinforced □ Section**

$C_1 + C_2 = T = 0.36 f_{ck}\, x_u b + A_{sc}(F_{sc} - 0.45 f_{ck.})$

$T = 0.87\, f_y\, A_{st}$, $x_u = \frac{0.87 f_y A_{st} - A_{sc}(f_{sc} - 0.45 f_{ck})}{0.36 f_{ck}\, b.}$

- **Nominal Shear Stress**

$\tau_v = \frac{V}{b.d}$, $\tau_{cmax} = 0.631\sqrt{f_{ck.}}$, $\%pt = \frac{A_{st}}{bd}\times 100.$



- **Inclined Bars**

$V_s = V_V - \tau_{cbd} = 0.87 f_y A_{S_V} \frac{d}{s_v}(\sin\alpha + \cos\alpha)$

$S_v = 0.87 f_y\, As_v d(\cos\alpha + \sin\alpha)$,

$S_v = \frac{0.87 f_y\, As_v d}{v - v_c}$ $\quad V_c = \tau_c bd.$

- **Maximm Spacing: 0.75d or 450mm**
- **Development Length:** $L_d = \frac{\sigma_{st}}{4\tau_{bd}}\phi$
- **Longitudinal Reinforcement:**

$M_1 = M_1 + M_2$ $\quad M_k = \frac{T_u(1+d/b)}{1.7}$, $\frac{A_{st}}{bd} = \frac{0.85}{f_y}$

- **Slabs**

$\left(\frac{l_y}{l_x}\right) \le 2$, two way slab, $\left(\frac{l_y}{l_x}\right) > 2$ one way slab

Member	Max. reinfocement	Min. reinforcement
Column	6% of gross cross sectional area	0.8% of gross cross sectional area
Slab		0.15% for mild steel & 0.125 for HYSD bars
Beam	4% of gross sectional area for each compr-ession and tension	$\frac{A_{st_{min}}}{bd} = \frac{0.85}{f_y}$
Hanger bars in beams	0.2% of gross cross sectional area of beam	–
Side face reinforcement in beam	–	0.1% of the web area
Shear reincorcement	–	$0.87 f_y AS_v \frac{d}{s_v} \ge 0.4bd$

- **Short Column: Short if salenderness. ratio of both axes are less than 12.**

Lateral ties: Diameter of lateral ties is given by criteria of stiffness not by strength. Hence, it is independent of grade of steel.

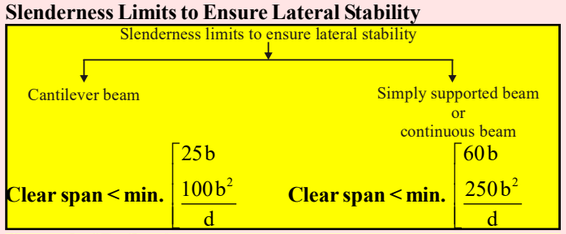
Tie diameter $\phi_t \ge \begin{cases} \frac{\phi_{longitudinal,\,max}}{4} \\ 6\ mm \end{cases}$, $S_t \le \begin{cases} D \\ 16\phi_{longitudinal,\,min} \\ 300\ mm \end{cases}$

Minimum Eccentricity

$e_{y,min} = \max\begin{cases} \frac{l_{ey}}{500} + \frac{D_y}{30} \\ 20\ mm \end{cases}$ For non – rectangular / circular section

$e_{x,min} = \max\begin{cases} \frac{l_{ex}}{500} + \frac{D_x}{30} \\ 20\ mm \end{cases}$ $\quad e_{min} = \max\begin{cases} \frac{l_e}{300} \\ 20\ mm \end{cases}$

Slenderness Limits to Ensure Lateral Stability


Slenderness limits to ensure lateral stability
Cantilever beam
Simply supported beam or continuous beam
Clear span < min. 25b, 100b²/d
Clear span < min. 60b, 250b²/d

Control of Deflection:

Cantilever beam	7
Simply supported beam	20
Continuous beam	26

Type of slab	Mild steel	Type of reinforcement Fe 415
Simply supported	35	28
Continuous	40	32

- **Concentrically Loaded Column (e=0)**

$P = 0.45 f_{ck}\, A_y + 0.75 f_y\, A_{st}$

- **Axially Loaded Column. (e < 0.05h)**

$P_w = 0.9P = 0.4 f_{ck} A_c + 0.67 f_y A_{st}$

Prestressed Concrete:

- **Loss due to length effect = $P_o k.x$**
- **Loss due to curvature effect = $P_o.\mu.\alpha$**
- **Loss of pre-stress at the**

Anchoring stage $= \frac{\Delta L}{L}\times E_s$

E_S = Young's Modulus for tension wires, L = length of tendon

- **Loss of stress due to shrinkage of concrete = $e_{sh} x\, E_s$**
- **Loss of stress due to creep of concrete = $\phi.m.f_c$.**
- **Losss of stress = strain lost in steel x E_S**

$\frac{f_c}{E_c}\times E_s = \frac{P_0}{A} + \frac{N}{Z}$

Types of prestressing on various basis-
Source of force - Hydraulic, electrical, mechanical, chemical.
Time of force application - pretensioning & post-tensioning.
Place of force application - External like as in bridges, internal like as in sleepers.

System (Country)	Type of tendon	Range of force	Arrangement of tendons in duct	Type of Anchorage
Freyssinet (France)	Wires & stands	Medium Large	Annular, spaced by helical wire core.	Concrete wedge
Lee-mc-call (Great Britain)	Bar threaded at ends	Small medium large	Single bars	High strength nut
Gifford-Udall (Great Britain)	Wires	Small & medium	Evenly spaced by perforated spacers	Split Conical wedge
Magnel-Blaton (Belgium)	wires	Small medium large	Horizontal rows of 4 wires spaced by metal griller	Flat steel wedge in sandwich plates

Stress	Grade of Concrete M_{20}	M_{25}	M_{30}	M_{35}
• Direct Tension	1.2	1.3	1.5	1.6
• Bending Tension	1.7	1.8	2.0	2.2

Total of Loss	Pretensioned	Post tensioned
(1) Elastic shorting of concrete	3 %	1 %
(2) Creep in concrete	6 %	5 %
(3) Shrinkage of concrete	7 %	6 %
(4) Relaxation of steel	2 %	3 %
	18%	15%

S.No	Type of Construction	Min. Grade
1.	Lean Concrete bases	M5, M 7.5
2.	Plain Concrete Cement	M 15
3.	RCC (general construction)	M 20
4.	Water tanks, dome	M 30
5.	In sea water	M30(RCC) M20 (PCC)
6.	Post-tensioned PSC	M 30
7.	Pre - tensioned PSC	M40

	Pre – tensioning	Post – tensioning
Stages	Anchoring of tendons, placing jacks, applying tension, casting concrete & finally cutting of tendons.	Casting of concrete, placing tendons, placement of anchorage block & jack, applying tension to tendons & finally seating wedges
Devices	Prestressing bed, Jack, Anchoring device, End Abutments, Shuttering/mould, Harping device	Casting bed, Ducts, mould/Shuttering, Anchoring devices, Jacks.
Advantages	• Suitable for Large scale production • Do not required Large anchorage device	• Heavy casting place members can be easily post-tensioned • Transfer of prestress is independent of length • Less waiting period in casting bed
Disadvan – tages	• Good bond is neccessary between transmission length. • Pre-stressing bed required	• Requirement of anchorage device & grouting equipment.

CIVIL ENGINEERING ROCKET CHART
FOR QUICK REVISION
BY
S.SOROUT: 9255624029
DISTRIBUTOR
GOLDEN BOOK DEPOT
DELHI (9811421791)

Admixtures: Plasticizers, Superplasticizers, Air entrainers, Accelerators, Retarders

NDT Test on Hardened Concrete: Maturity test, Pull-out test, Penetration test, Ultrasonic pulse velocity test

Fineness Modulus: It is an index number which is roughly proportional to the average size of the particles in the aggregate.

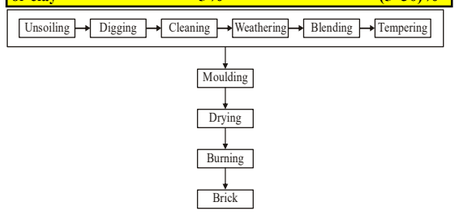
It is the sum of cumulative percentage retained on the sieves of the standare sieves: 150 μm, 300 μm, 600 μm, 1.18 mm, 2.36 mm, 4.75 mm, 10 mm, 12.5 mm, 63 m and 80 mm.

Higher Fineness modulus aggregate results in harsh concrete mixes and lower Fineness modulus results in uneconomical concrete mixes.

Order of Aggregates: Strength– Cubical > Crushed> Rounded > flaky, Workability – Rounded > Cubical > Crushed > flaky

Property	1st class	2nd class	3rd class
Compressive strength (N/mm^2)	≥ 10.5	≥ 7.0	3.5
Water Absorption	20%	22%	25%
Uses	Pointing & Important work	RB work & Hidden masonry work	Unimportant temporary stru.

Poor lime	Fat lime	Hydraulic lime
Impure/lean lime Contain more than 30% of clay	Pure/Rich/White lime Impurities are less than 5%	Water lime Impurties (5–30)%



Flowchart: Preparation of Brick Earth

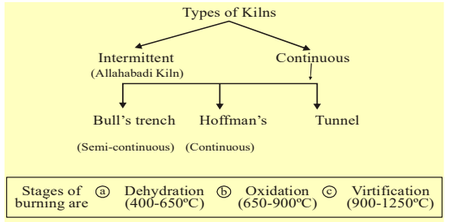
- **Moulds are made (8–12)% larger in size.**
- **To prevent the moulded bricks from sticking to the side of the mould, sand is sprinkled on the inner sides of the mould.**

Drying: If green bricks burnt, it can get cracked & distorted.

Types of Drying - (a) Natural drying

(b) Artificial drying - (i) Hot floor drier, (ii) Tunnel drier.

- **In clamp burning process, at 15^0 angle bricks are to be laid.**
- **The percentage of moisture in wet bricks is 7- 30%**
- **The wet bricks should be dried in an open atmosphere 4-5 days**

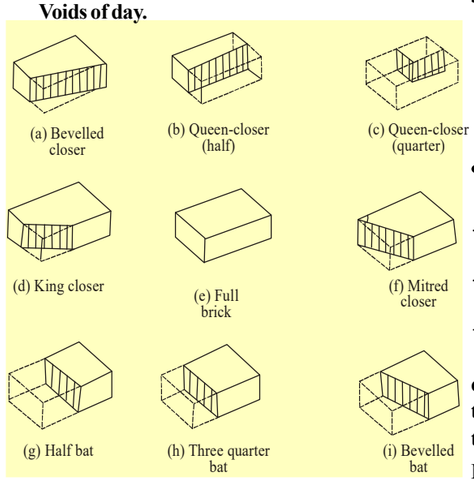


Comparison between clamp Burning and Kiln Burning

S. No.	Item	Clamp burning	Kiln burning
1.	Capacity	About 20000 to 100000 bricks can be prepared at time	Average 25000 can be prepared per day.
2.	Structure	Temporary structure.	Permanent struct.
3.	Initial cost	Very low as no structures are to be built	More as permanent structures are to be constructed.
4.	Quality of bricks	small.	more.

Defects of bricks

1. **Over burning: Bricks loose their shape.**
2. **Blisters: Formed due to air imprisioned during their moulding.**
3. **Bloating: Spongy swollen mass over bricks surface due to excess of carbonaceous and sulphur matter.**
4. **Efflorescence: Due to alkalies.**
5. **Chuffs: Deformation of shape of the bricks caused by the rain water falling on hot bricks.**
6. **Under burning:Higher water absorption and less compressive strength.**
7. **Laminations: It is due to entrapped air in the Voids of day.**



S.SOROUT, 9255624029

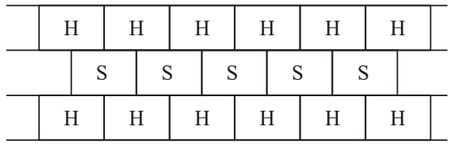
FOLLOWING BOOKS AVAILABLE BY

CIVIL Ki GOLI PUBLICATION:

1. **CIVIL Ki GOLI**
2. **CIVIL BOOSTER**
3. **REASONING Ki GOLI**
4. **HARYANA Ki GOLI**
5. **SOLUTION OF CIVIL Ki GOLI**
6. **ELECTRICAL & MECHANICAL ENGINEERING ROCKET CHART**
7. **UTTAR PRADESH Ki GOLI**
8. **UTTRAKHAND Ki GOLI**
9. **PUNJAB Ki GOLI**
10. **WEST BENGAL Ki GOLI**
11. **HINDI ROCKET CHART**
12. **CIVIL CAPSULE**

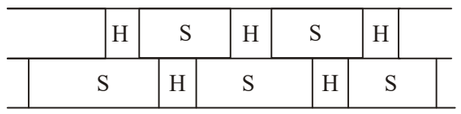
Types of bonds

1. **Stretcher bond: All the bricks are laid as Stretchers on the faces of the wall.Used for constructing 10 cm thick brick partition wall.**
2. **Header bond: All the bricks are laid as headers on the faces of the wall. Commonly used for constructing staining of wells, corbels, footing etc.**
   - **It is using three-quarter brick bats in each alternate courses as quoins.**
3. **English bond: Alternate courses of headers & stretchers.**
   - **English Bond is stronger & costly than flemish Bond.**
   - **Mostly English bond is used in government work**
   - **Adopted for work where strength is of prime importance.**



4. **Facing bond : Bricks of different thickness are to be used in the facing or backing of the wall.**
5. **Flemish bond: Each course has alternate header & stretcher.**
   - **Flemish Bond give better appearance than English Bond.**
   - **Construction with flemish Bond requirs greater skill in comparison to English Bond & bat bricks are use in it.**

- **Minimum width of wall for single flemish bond is 1½ brick wall.**



Slenderness ratio of brick masonry:It is the effective height of the wall divided by effective thickness or effective length divided by effective thickness, whichever is less.

Maximum slenderness ratio for load bearing walls

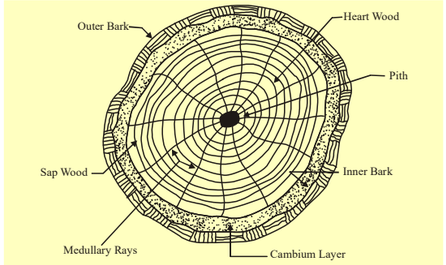
No. of storeys exceeding 2	Using Portland cement or pozzolana cement	lime mortar
Not exceeding 2	27	30
exceeding 2	27	12

Classification of Walls									
Load bearing wall					Non load bearing wall				
Solid wall with piers (Pilasters)	Veneered wall	Cavity wall	Solid wall	Faced wall	Partion wall	Panel wall	Free standing wall	Curtain wall	Faced wall

Types of trees		
Endogenous tree These grow inward Bamboo, Cane, Palm	Exogeneous tree These grow outward Deodar, Sal, Teak	
	Conifers (soft wood) Needle shape leaves Evergreen tree Pine, Chir, Deodar	Deciduous (hard wood) Broad shape leaves Open tree Oak, Teak, Shishum

Comparison of softwood and Hardwood

Property	Sotwood	Hard-wood
Colour	Lighter	Darker
Growth	Faster	Slower
Weight	Lighter	Heavier
Density	Low	High
Annual rings	Distinct	Indistinct
Heart-wood	Can not be distinguished	Canbe distinguished
Strength	Strong along grains	Strong along & across grains
Conversion	Easy	Difficult
Resinous Material	Exist in pores	Does not exist
Examples	Chir, Fir, Kali, Pine, Deodar	Teak, Sal, Shishum, Poplar and Maple



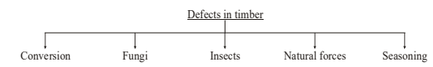
Sawing of Timber

- ***Ordinary*→ Flat/slab sawing: It is very quick & Economical method.**
- ***Tangential Sawing*→ Cutting is tangential to the Annual rings & at right angles to the meduallary rays.**
- ***Radial Sawing*→ Sawing is done Parallel to the rays & perpendicular to the rings: It give strongest timber**
- ***Quarter/Rift Sawing*→ Quarter sawn wood wears better & shrink more evenly.**

Note: Radial sawing will produce the strongest timber piece as in redial sawing medulary rays are not out as the sawing is done parallel to the rays.

Properties of Timber:

1. **Specific gravity of wood = 1.54**
2. **Weight of timber should be noted at 12% moisture content**
3. **Timber is Anisotropic & Elastic material, shrinks least along length and maximum along circuferance**
4. **Fibre saturation point is % moisture content at which cell walls are saturated and cell cavity contains no water.**



1. Conversion defects

- (*i*) **Chip mark: These are the marks or signs placed by chips on finished surface of timber.**
- (*ii*) **Wane:It is the presence of original rounded surface on the manufactured timber.**
- (*iii*) **Diagonal grain: Improper sawing, Indicated by diagonal mark or straight grained surface of timber.**
- (*iv*) **Torn grain: It is the small depression on the finished surface due to falling of tool**

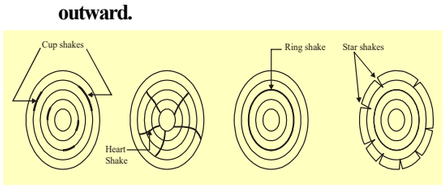
2. Defects due to fungi:

- (*i*) **Blue stain: Sap of wood is stained to bluish colour**
- (*ii*) **Sap Stain: Fungi feeds on cell contents of sap wood, then the sap wood looses its colour**
- (*iii*) **Dry rot: It occurs due to lack of ventilation/ absence of sunlight (in basements, rooms or in damp situations like kitchen.)**
- (*iv*) **White rot: The fungi attacks on lignin of wood & wood assumes the appearance of white mass consisting of cellulose compounds**
- (*v*) **Brown rot: Fungi of certain type remove cellulose compounds from wood & it attains brown colour.**
- (*vi*) **Heart rot: In it, heart wood is exposed to atmosphere & attacked by atmospheric agents.**
- (*vii*) **Wet rot: It is the chemical decompositons of wood due to alternate dry & wet conditions**

4. Defects due to Natural forces:

- (*i*) **Burls, (*ii*) Callus, (*iii*), Dead wood, (*iv*) Knots**
- (*v*) **Foxiness, (*vi*) Druxiness, (*vii*) Rind galls**
- (*viii*) **Shakes: Longitudinal separations in the wood between the annual rings**

  (a) Heart Shake: Occurs in overmatured trees. These are wider at centre & diminish outward.



Prevsevation of Timber (IS : 401)

Types of Preservatives:

- (*a*) **Ascu Treatment: It was developed by forest Research Institute, Dehradun. This solution is odourless**

  Solution is made by 6 parts of posder in 100 parts of water by weight. Preservtive gives protection against white ants.

$$AS_2O_5.2H_2O + CuSO_4.5.H_2O + K_2Cr_2O_7/Na_2Cr_2O_7.2H_2O$$

1 Part 3 Parts 4 Parts

Mixed in powdered form

- (*b*) **Chemical Salts, (*c*) Oil points,**
- (*d*) **Solignum paints:**
- (*e*) **Coal tar: Surface is coated with hot coal tar with the help of brush. This process is called tarring. It is fire resistant.**
- (*f*) **Creosote oil: The application of Creosote oil on timber is called creosoting. It is highly toxic in nature. It is obtained by distillations of tar. It is one of the best antiseptic. It is black or brown liquid weakly affected by water, neither volatile nor hygroscopic.**

Chemical Composition of Raw materials

Oxide	Composition (%)	Function
Lime, CaO	60–65	It control strength and soundness.
Silica, SiO_2	17–25	Excess of it causes slow setting
Alumina, Al_2O_3	3–8	Responsible for quick setting, excess of it lowers strength
Iron oxide Fe_2O_3	0.5–6	Gives colour and helps in fusion of different ingredients
Magnesia, MgO	0.1 –4	Give colour and hardness
Soda and Potash Na_2O and K_2O	0.5–1.3	If in excess causes efflore-scence & cracking
Sulphur trioxide SO_3	1–3	Makes cement sound

Silica Iron oxide
Loss me h A I M S → Sulphur Trioxide
Lime Alumina Magnesia

456 Plain and reinforced concrete
269 Specification of OPC 33 grade
8112 Specification of OPC 43 grade
12269 Specification of OPC 53 grade
8041 Rapid hardening Portland cement
8042 White Portland cement
8043 Hydrophobic Portland cement
IS:6452 High alumina cement
IS:1489 Part-I Portland Pozzolana cement (fly ash based)
IS:1489 Part-II Portland Pozzolana cement (Calcined clay)
383 Coarse & fine aggregates from natural sources
516 Strength of concrete tests
650 Specification for standard sand for testing
2386 Test for Aggregate (1–8 Parts)
2430 Sampling of aggregate for concrete
5816 Splitting tensile strength of concrete
6461 Glossary of terms related to cement concrete (Part 1–12)
7320 Specification of concrete slum test apparatus
10262 Guidelines for concrete mixed design
875 Design loads (other than earthquakes) for building & structures
Part I : Dead load. Part II: Live load
Part III : Wind load, Part IV : Snow load
Part V : Special loads & load combinations
1893 Earthquake resistant design for structures

Note: The new code for all OPC 33, 43 & 53 grade is IS 269:2015

CIVIL ENGINEERING ROCKET CHART
FOR QUICK REVISION
BY
S.SOROUT: 9255624029

Bogue's Compound

Principal Mineral Compound	Formula	Symbol	Function
Tri calcium Silicate (Alite)	$3CaO.SiO_2$	C_3S	7-day strength and Hardness
Dicalcium silicate (Belite)	$2CaO.SiO_2$	C_2S	Ultimate strength
Tricalcium Aluminate (Celite)	$3CaO.Al_2O_3$	C_3A	Flash–set
Tetra calcium Alumina Oxide (Felite)	$4CaO.Al_2O_3.Fe_2O_3$	C_4AF	Poorest cementing value

Water Requirement for hydration
Bound water=23% by weight of cement.
Gel water=15% by weight of cement
Total minimum = 38%

Property	Dry Process	Wet Process
Temperature range	1400-1500°C	1500-1600°C
Gypsum amount	2-3%	3%
Economically (in fuel)	Less	More

Material	Unit weight (kN/m³)
Brick Masonry	19 – 20
Plain cement concrete	22–24
Reinforced cement concrete	24–25
Cement mortar	20–21
Steel	78–80
Cement	14.4

Types of Cement

1. Portland cement: Classified on the basis of manufacturing as 33 grade, 43 grade and 53 grade.
OPC
(i) OPC-33 (IS : 269-2015)
(ii) OPC-43 (IS : 8112-1989)
(iii) OPC-53 (IS : 12269-1987)
Initial Setting Time (IST) – 30 minute & final Setting Time (FST) – 600 minute
2. Rapid hardening cement (IS:8041): More C_3S and less C_2S as compared to OPC
   - Not-used in mass concrete & it produce Large Shrinkage
   - RHC attains same strength in 1 day which an OPC attains in 3 days with same w/c.
   - It is suitable for repair of roads, bridges etc.
3. Extra Rapid hardening cement: Rapid hardening cement + 2% $CaCl_2$ (also called calcium chloride cement)
   - Especially used in cold weather but also give Excessive Shrinkages
4. High alumina cement (IS:6452):
IST – Min. 3 hour 30 minute & FST – Max. 5 hour.
It is used for refractory conerete, industries & used widely in Pre-casting.
   - Particularly suitable to sea and under-water work
   - Widely used in Pre-Casting, Expansion ≤ 5 mm
5. Portland Slag cement: The mixture of portland cement, granulated blast furnace slag & Gypsum
   - High Sulphate resistance & it is Used in mass concreting work.
6. Super Sulphated Portland cement : 80–85% Granulated slag + 10– 15% calcium sulphate + 5% Portland cement clinker.
   - It is resistant to chemical attacks particularly to sulphate & highly resistant to sea water
   - It should not be used with any admixture
7. Low heat Portland cement: Low C_3S and C_3A and more contents of C_2S
It is use in mass concrete work
   - Rate of development of strength is low but ultimate strength is same
8. Portland Pozzolana cement (IS:1489 Part-I) : OPC + 10– 30% of fly ash by mass of PPC it is use in marine work.
   - Free lime is removed, hence, resistant to chemical attack increases

Note: Puzzolana has no cementing property in itself but when it combines with lime, it produces a stable lime pozzolana compound which has cementious property.

The addition of pozzolanas to conncrete results in.
(a) Improvement in durability by reducing permeability
(b) Reduction in shrinkage.
(c) Increase in workability of concrete.
(d) Deduction in the rate of hardening of concrete.
(e) Reduction in segregation and bleeding of concrete.
(f) Increased resistance against sulphate attack (reduction in chemical action with sulphates).

9. Quick setting cement: Fine grounded OPC with reduced Gypsum content & small amount of aluminium sulphate.
   - IST = 5 minutes & FST = 30 minutes
   - Used in under water concreting.
10. White and Coloured Portland cement (IS: 8042) : From Pure white chalk, china clay & Iron Oxide should not be more than 1%.
   - These are used for making Terrazzo flooring, ornamental works & casting stones.
   - Hunter scale is use for checking the whiteness of cements
   - 5–10% Colouring pigment before grinding
11. Air Entraining cement: OPC + Vinsol resin or vegetable fats of oils or fatty acids.
   - Small amount of (0.1%) by weight of an air entraining agent.
12. Water Repellent or Hydrophobic cement: OPC + fractions of olic acid, Stearic acid or pentachlorophenol.
   - Suitable for basement and making water tight structures.

Minimum Specified Strength in N/mm²			
Type/days	1 day	3days	7 days
28 days			
OPC (33 grade)	–16.0	22.0	33.0
Portland Pozzolana	–16.0	22.0	33.0
Low heat Portland	–10.0	16.0	35.0

Test of Cement

• FINENESS TEST	• Sieve Method
	•Air permeability Method
	• Sedimentation mehtod
• CONSISTENCY TEST	• Vicat's Apparatus.
• SETTING TIME	• Vicat's Apparatus.
• SOUNDNESS TEST	• Le-chatelier Method • Auto clave test
• TENSILE STRENGTH	• Briquette test
• HEAT OF HYDRATION	• Calorimeter test
• SPECIFIC GRAVITY TEST	• Le-chatelier's Flask.

Consistency Test: It is the Amount of water used to make paste of normal consistency. It is about 30% generally. It is the percentage of water required for the cement paste, the viscosity of which will be such that Vicat's plunger penetrates upto 5 to 7 mm from bottom (33 to 35 mm from top) of the Vicat's mould.

Attahment	Use
1. Plunger, 10 mm dia, 50 mm long	Consistency test
2. 1 mm × 1 mm square needle	Initial setting time
3. 5 mm dia Annular collar	Final setting time

S. No.	Types of test	Diameter or size	Shape
1.	Initial setting time	1mm of square needle	
2.	Final setting time	5mm annualar ring	
3.	Consistency	10mm solid circular	

Soundness Test: To detect change in volume after setting

Le–Chatelier method	Auto clave test
Measure unsoundness (free lime only)	Sensitive to both lime & magnesia
100 gm of cement + 0.78 P water	Internal mould dimension (25 × 25 × 282) mm
Result is given in "mm"	Result is given in %

Strength determination

Compressive strength	Tensile strength
• Cube test (size 7.06cm)	• Briquette test (6.45 cm^2), 6 no.
• Cement (185 gm) + Ennore sand (555 gm), ratio of 1 : 3	• T.S = (10 – 15)% of compressive strength • Generally used for RHC
• Water = $\left(\frac{P}{4}+3\right)$%	• Cement : sand = 1 : 3
• Temperature 27 ± 2°C	
• Atleast 3 cube for testing	• Water = $\left(\frac{P}{5}+2.5\right)$%
• Rate of loading:- 140 Kg/cm^2 /min	• Rate of loading:- (1.2 - 2.4)N/mm^2/min

CIVIL BOOSTER - Dnt trust us, Just Check it's content & Then Go for it - (LEAVE THE REST, GET THE BEST) . Available on amazon flipkart.

Type of formwork	Minimum period before stricking formwork
(a) Vertical formwork to columns, walls, beams	16-24 h
(b) Soffit formwork to slabs (props to be refixed just after removal of formwork)	3 days
(c) Soffit formwork to beams (Props to be refixed just after removal of formwork)	7days
(d) Props to slabs	
(i) Spanning up to 4.5m	7 days
(ii) Spanning over 4.5m	14 days
(e) Props to beams and arches	
(i) Spanning up to 6 m	14 days
(ii) Spaning over 6 m	21 days

Concrete classification (Based upon)				
Cementing material	Bulk density	Grade of cement	Perspective specification	Place of casting
Lime concrete Gypsum concrete Cement concrete	Extra light <500 kg/m^3 Light 500-1800 kg/m^3 Dense weight 1800-2500 kg/m^3 Super heavy weight > 2500 kg/m^3	Low strength <20 N/mm^2 Medium strength 20-40 N/mm^2 High strength > 40 N/mm^2	1 : 4 : 8 → M7.5 1 : 3 : 6 → M10 1 : 2 : 4 → M15 1 : 1.5 : 3 → M20 1 : 1 : 2 → M25	In Situ concrete Precast concrete
			Use CIVIL Ki GOLI for Remembering	

Test on Concrete

• WORKABILITY	• Slump test
	• Compacting factor Test
	• Vee-bee consistometer method
• DIRECT TENSILE STRENGTH OF CONCRETE	•Cylinder Splitting TEST
• BOND B/W CONCRETE & STEEL	• Pull out Test
• COMPRESSIVE STRENGTH	• Rebound hammer
• DYNAMIC MODULUS OF ELASTICITY	• Resonant Frequency

Manufacturing of Concrete: Batching → Mixing → Transporting → Placing → Compacting → Finishing → Curing

Methods of Curing:

(*a*) Shading
(*b*) Covering surface with wet hessian cloth or gunny bags
(*c*) Sprinkling
(*d*) Ponding
(*e*) Steam curing (For precast members)
(*f*) Applying curing compounds

Compressive strength test:

- Size of coarse aggregate upto 38 mm
- Size of cube – 150 × 150 ×150 mm
- Size of cylinder – 150 mm dia, 300 mm height
- Cube mould filled in 3 layers, tempered 35 times per layer with tampering rod of 16 mm dia & 600 mm length.
- Stored at temp of 27 ± 3°C at 90% humidity for 24 ± 1/2 hour.
- Then immersed in water for 7 days or 28 days.
- Rate of loading in compression testing machine = 14 N/mm ²/ minute.

Cube strength = 1.25 × Cylinder strength

Defects in Concrete: Cracks, Crazing,Efflorescence, Segregation, Bleeding